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ABSTRACT

Piaget's model of children's conceptual learning and development was compared with Klausmeier's Conceptual Learning and Development (CLD) model in a longitudinal study. The CLD model suggests four successive levels of concept learning: (1) concrete--recognizing an object which has been encountered previously; (2) identity--recognizing a known object when it appears in a different spatial, time, or sensory perspective; (3) classificatory--generalizing that two items are alike in some way; and (4) formal--naming and defining the concept, listing its attributes, and judging the presence of such attributes in an object. The CLD assessment batteries, designed to assess the attainment level and use of three concepts (equilateral triangle, noun, and tree), Piagetian logical concept tasks assessing classificatory, relational, numerical, and conservation abilities; and three memory measures were administered to 180 kindergarten, third, and sixth grade children. One year later, 156 of these subjects were tested again; data on these subjects are summarized for the first two years of study. Results of pass/fail contingency analyses relating performances on the various measures are given, as well as results of correlational and factor analyses. (Author/GDC)

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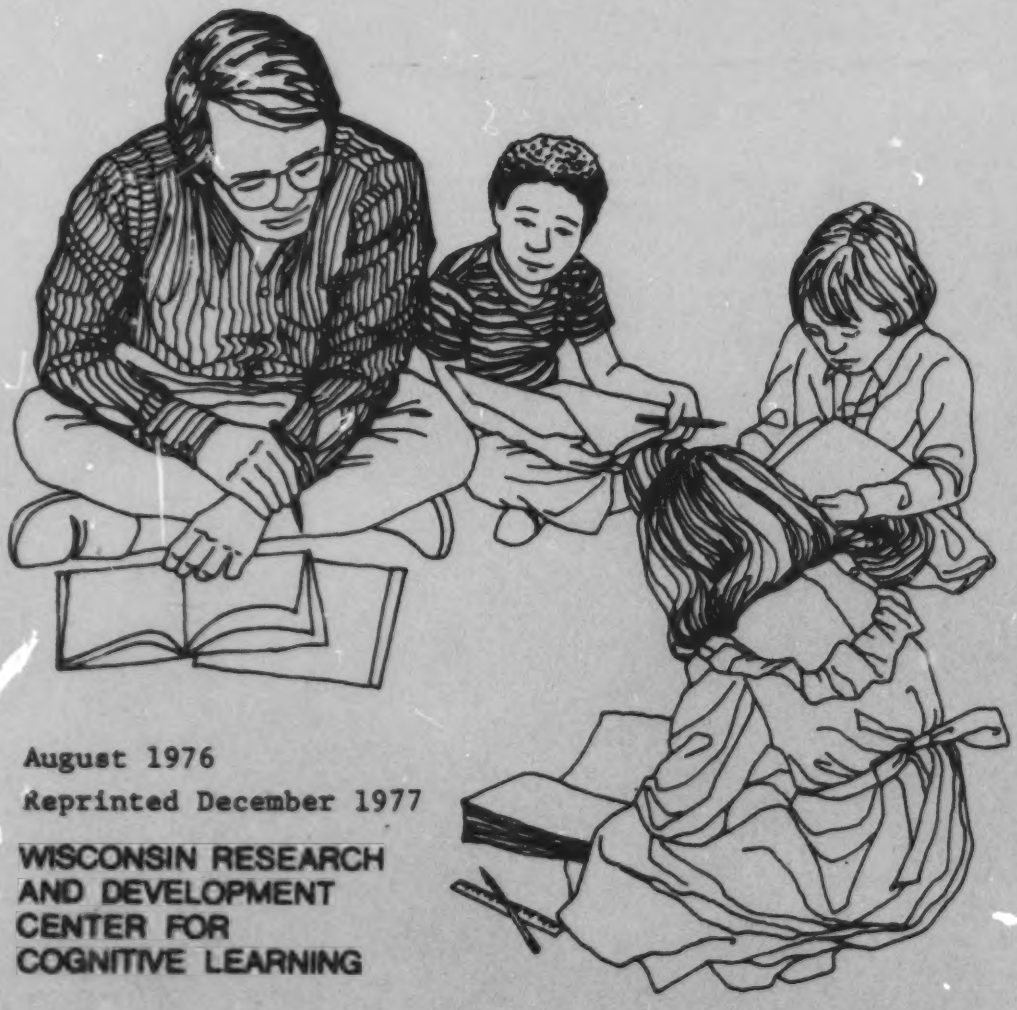
Technical Report No. 426

A PRELIMINARY REPORT OF THE RELATIONSHIP BETWEEN PIAGET'S AND KLAUSMEIER'S MEASURES OF CHILDREN'S COGNITIVE DEVELOPMENT

by Herbert J. Klausmeier, Frank H. Hooper, and Thomas S. Sipple



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WISCONSIN RESEARCH AND DEVELOPMENT CENTER FOR COGNITIVE LEARNING

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Report from the Program on
Children's Learning and Development

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Faculty Associates

Wisconsin Research and Development
Center for Cognitive Learning
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ABSTRACT

This paper presents the general purposes and orientation of a four year longitudinal study of the relationships among children's conceptual learning and development as described by the Conceptual Learning and Development (CLD) model and the constructs and principles of Piagetian theory. The assessment instruments and procedures used with a sample of children aged 5 to 12 years are described. The CLD assessment batteries employed were designed to measure level of attainment and use of each of the concepts equilateral triangle, noun, and tree. The battery based upon Piagetian theory consisted of logical concept tasks assessing classificatory abilities, relational abilities, number concepts, and conservation abilities. In addition, three memory measures were selected.

Of the 180 children (60 at each grade: kindergarten, third, and sixth) tested in the initial year (1973) of the study, 156 children were available for longitudinal assessment twelve months later in 1974. The data collected over these first two years of longitudinal assessment on these 156 subjects are summarized and reported. Results of pass/fail contingency analyses relating performances on the various measures are given as well as results of correlational and factor analyses.

I

GENERAL PURPOSES AND ORIENTATION OF THE STUDY

The present interrelationship analyses are an integral element of a large scale investigation of children's cognitive development and concept learning (Hooper & Klausmeier, 1973). The analyses were undertaken to identify possible relationships among constructs and principles of Piagetian theory and a theory of conceptual learning and development (CLD) (Klausmeier, Ghatala, & Frayer, 1974). Assessment tasks and procedures derived from Piagetian theory were selected by Hooper. The assessment batteries dealing with the theory of conceptual learning and development were constructed and validated by Klausmeier and associated project personnel.

The concepts, cognitive operations, and cognitive structures of the human organism undergo radical quantitative and qualitative change from birth to maturity. The present study focuses on the changes during the time span of 5 to 12 years of age. The changes during these years include marked improvements in the cognitive operations[1] of attention, discrimination, memory, and generalization, as well as notable advances in language functioning (Klausmeier, Ghatala, & Frayer, 1974).

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[1]The term, cognitive operations, as employed in the present study, refers to the underlying process abilities designated in the CLD model. In contrast, the term logical operations designates the special constructs employed by Piaget and his Genevan associates.

From the Piagetian perspective, the child progresses from the pre-logical status of the preoperational period through the period of concrete operations to the beginnings of formal reasoning.

It is clear from the previous normative research that the cognitive developments as described in both the CLD and Piagetian theories proceed in a parallel fashion and both sets of developments are distinctly age related. This orientation, of course, does not view age as a causal variable but rather as an additional dependent variable which covaries with the focal measures at issue (Wohlwill, 1973). While it is undoubtedly true that the cognitive developments specified in both theories change from 5 to 12 years of age, no empirical investigations to relate the changes proposed in the two theories have been conducted to date.

The explicit purpose of the present study is an investigation of the interrelations between children's performances on assessment batteries based on CLD theory and on specially developed tasks dealing with the logical operations specified by Piagetian theory. No attempt will be made in this relationship study to test or validate either of these models of cognitive development and learning. Rather, our orientation is directed toward a more complete understanding of the explanatory and predictive value of the developments specified by the respective theories. Descriptions of the construction and validation of the CLD assessment batteries (e.g., Klausmeier, Bernard, Katzenmeyer, & Sipple, 1973; Klausmeier, Ingison, Sipple, & Katzenmeyer, 1973a, 1973b; Klausmeier, Marliave, Katzenmeyer, & Sipple, 1974) and

comprehensive accounts of the results of the first two years' assessments that were completed on the children reported in this study have been published previously (Klausmeier, Allen, Sipple, & White, 1976a 1976b; Klausmeier, Sipple, & Allen, 1974b). In similar fashion, the procedural details and psychometric characteristics of the Piagetian tasks used in this study have been presented (Hooper, Brainerd, & Sipple, 1975) while the initial results of the cross-sectional (year one) and longitudinal Piagetian analyses have been reported in Brainerd and Hooper (1975), Dihoff (1975, 1976), Gonchar (1975), Hooper, Swinton, and Sipple (1976), Hooper and Toniolo (1976), and Toniolo and Hooper (1975). Thus, three kinds of investigations are proceeding simultaneously and the results are being reported accordingly. First, Hooper and his colleagues and staff are conducting and reporting cross-sectional and longitudinal investigations regarding Piagetian theory; children of age 5 to 12 participate in these studies. Second, Klausmeier and his staff are conducting and reporting cross-sectional and longitudinal investigations regarding CLD theory; children of age 5 to 18 are participating in these studies. Third, Hooper and Klausmeier are conducting this relationship study; the same sample of the children of age 5 to 12 who are part of the preceding investigations comprise the sample of this investigation. To relate various considerations regarding Piagetian theory and CLD theory, we are examining the correspondence among Piaget's unitary logical model of classes and relations as measured with a test constructed by Brainerd (1972); operations during the period of concrete operations as measured with widely-used

experimental tasks of these operations; e.g., seriation, transitivity, conservation; and cognitive development as defined in CLD theory, which development includes systematic changes both in the learning operations of the individual and the related cognitive structures. The use of terms to indicate central processes in the CLD theory--attenting, discriminating, generalizing, hypothesizing, inferring, remembering, and evaluating--conform closely to that of American learning theorists; the cognitive structure of the individual is regarded as the organized information the individual has regarding the physical and social world. This view of cognitive structure parallels that of Ausubel (1968) and corresponds closely to the construct of "Image" as explained by Miller, Galanter, and Pribram (1960).

In Chapter II, an overview of the model of conceptual learning and development is presented so that the reader will be able to relate its major features to the present study. In Chapter III, a brief overview of Piagetian constructs germane to the present study are given for the same purpose. Chapter IV gives the procedures followed in the present study. Chapters V and VI respectively, give the results of the first and second data collections. We point out that since data collection continued for two more years, final conclusions and discussions will appear in a final report that includes the results of the data collected throughout the longitudinal study.

II

OVERVIEW OF THE MODEL OF CONCEPTUAL LEARNING AND DEVELOPMENT

Concepts, principles, and problem-solving skills have long been recognized as the primary outcomes of learning in the cognitive domain (National Society for the Study of Education, 1950). Concepts, when considered as mental constructs of the individual, are the building blocks for learning principles and problem-solving skills and of thinking itself (Kagan, 1966). Concepts, when considered as the meanings of words that are common to persons who speak the same language and who have similar cultural experiences (Carroll, 1964), comprise a substantial part of many subject matters and are the basic unit of instruction in those subject matters.

Knowledge about concept learning has been extended through early experimentation conducted in laboratory settings using experimenter created populations of concepts as reported by Bourne, Ekstrand, and Dominowski (1971), and Bruner, Goodnow, and Austin (1956). More recently, the variables that are relevant to the learning and teaching of subject matter concepts are being manipulated in school settings (Klausmeier, Ghatala, & Frayer, 1974; Klausmeier & Feldman, 1975; Markle & Tiemann, 1969; Markle, 1975; Tennyson, Woolley, & Merrill, 1972). Knowledge about concept learning and also about conceptual development during the school years has been synthesized into a model of conceptual learning and development (see CLD model by Klausmeier, Ghatala, & Frayer, 1974). In this chapter the essential

features of the theory are explained and predictions based on the theory are indicated.

THEORY REGARDING THE ATTAINMENT OF CONCEPTS

The essential elements of the CLD model are presented first and then predictions based on the theory are indicated.

Essential Elements of the CLD Model

An analytic descriptive model of conceptual learning and development incorporating an integrative approach to theory building was formulated (Klausmeier, 1971; Klausmeier, Ghatala, & Frayer, 1974). The model provides a theoretical framework for research on conceptual development and learning during the school years. According to this model, normally developing children and youth attain the same concept at four successively higher levels. Maturing individuals are able to progress from one level to the next as they become capable of the prerequisite mental operations of a particular level and as they have attained the concept at the prior level. The ability to learn a concept at each of the four successive levels is explained, first, in terms of the individual being capable of the prerequisite mental operations and, second, in terms of the external conditions that facilitate learning at a particular level. The initial manifestation of a particular mental operation at each level is presumed to be a product of both maturation and learning, or more broadly, of development. The external conditions for learning concepts include instruction designed specifically for particular students at their particular levels of conceptual development.

As shown in Figure 1, a concept is attained at four successively higher levels: concrete, identity, classificatory, and formal. A concept learned to a certain level may be used in various ways. Concepts acquired at only the concrete and identity levels may be used in solving simple problems that require only the relating of sensory perceptions. However, concepts acquired at the more mature classificatory and formal levels may be used in identifying newly encountered instances as examples and nonexamples of the concept. They also may be used in understanding taxonomic and hierarchical relationships of which the particular concept is a part, in understanding principles involving the concept, and in solving problems.

Acquiring the name of the concept and the names of its defining attributes may come at any of the four levels; however, having the name of the concept and the names of attributes is essential to attaining concepts at the formal level. Individuals may acquire the name at about the same time they first attain the concept at lower levels, but this is not a prerequisite condition.

The prediction that a concept is attained at the four successive levels applies to concepts that: (a) have more than one example, (b) have observable examples or representations, and (c) are defined in terms of attributes. Not all concepts are of this kind. Some concepts have only one example, e.g., the earth's moon. Some do not have observable examples, e.g., atom, eternity, soul. Still others are defined in terms of a single dimension; e.g., rough, thin, or in terms of a relationship, e.g., south, between, above. While not all four levels are applicable to these kinds of concepts, the identity level is applicable to concepts that have only one

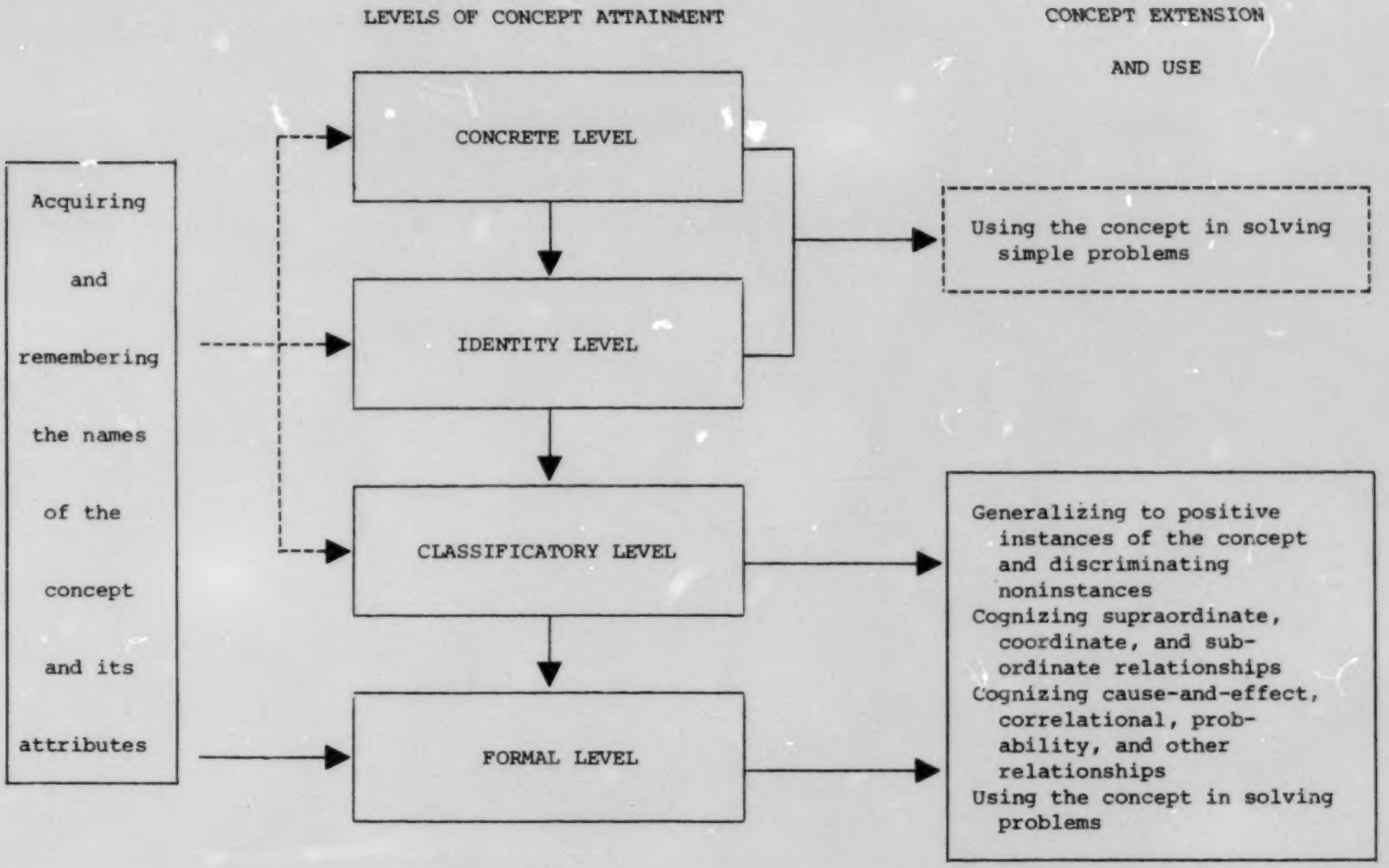
LEVELS OF CONCEPT ATTAINMENT
CONCEPT EXTENSION AND USE
Acquiring and remembering the names of the concept and its attributes
CONCRETE LEVEL
IDENTITY LEVEL
CLASSIFICATORY LEVEL
FORMAL LEVEL
Using the concept in solving simple problems
Generalizing to positive instances of the concept and discriminating noninstances
Cognizing supraordinate, coordinate, and subordinate relationships
Cognizing cause-and-effect, correlational, probability, and other relationships
Using the concept in solving problems

Figure 1. Levels of concept attainment, extension, and utilization.

example; the classificatory level is applicable to those of one dimension or expressing a relationship; and the formal level is to others that have no observable, classifiable examples. With this introduction to the four levels and the kind of concepts under consideration, the mental operations pertaining to each level will be discussed.

CONCRETE LEVEL

Attaining a concept at the concrete level is inferred when the individual recognizes an object that has been encountered on a prior occasion. The operations involved in attaining this level, as shown in Figure 2, are attending to an object, discriminating it from other objects, representing it internally as an image or trace, and maintaining the representation (remembering). The infant, for example, attends to a large red ball, discriminates it from other objects in the environment, represents the image of the ball internally and maintains the image (remembers), and recognizes the red ball when experienced later in the identical form as initially experienced.

IDENTITY LEVEL

Attainment of a concept at the identity level is inferred when the individual recognizes an object as the same one previously encountered when the object is observed from a different spatio-temporal perspective or sensed in a different modality, such as hearing or seeing. For example, the child's making the same response to the family poodle when seen from straight ahead, from the side, and from various angles is evidence of having attained the concept of the particular poodle at the identity

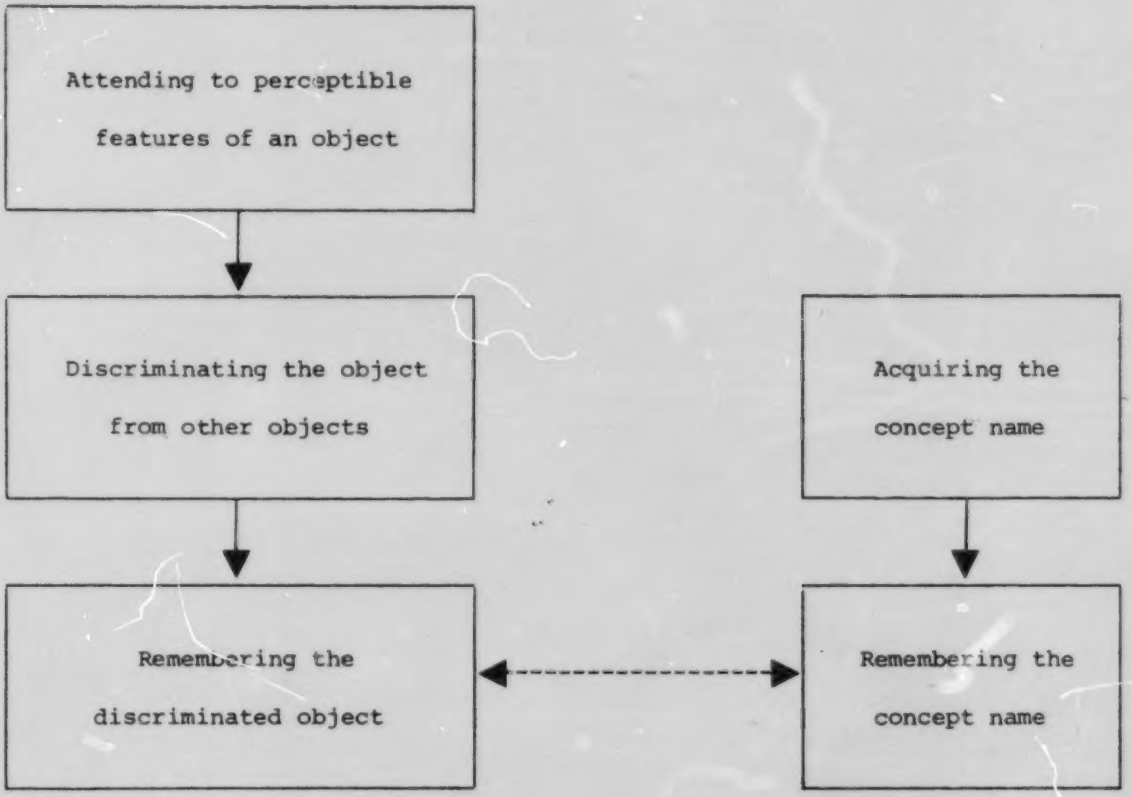
Attending to perceptible features of an object
Discriminating the object from other objects
Remembering the discriminated object
Acquiring the concept name
Remembering the concept name

Figure 2. Cognitive operations in concept attainment at the concrete level.

level. As shown in Figure 3, the operations of attending, discriminating, and remembering are involved in attainment at the identity level as they also are at the concrete level. However, whereas concept attainment at the concrete level involves only the discrimination of an object from other objects, attainment at the identity level involves both discriminating various forms of the same object from other objects and also generalizing the forms of the particular object as equivalent. Generalizing is the new operation postulated to emerge as a result of learning and maturation that makes attainment at the identity level possible.

Some psychologists (e.g., Gagné, 1970) treat concepts at the concrete and identity level as discriminations. Piaget (1970) refers to them as object concepts. The critical matter is not what they are called, but to explain the internal and external conditions of concept learning at these two lowest levels.

CLASSIFICATORY LEVEL

As shown in Figure 4, the new mental operation that makes possible attainment of concepts at the classificatory level is generalizing that two or more things are alike in some way. The lowest level of attaining a concept at the classificatory level is inferred when the individual responds to at least two different examples of the same class of objects, events, or actions as equivalent. For example, when the child treats the family's toy poodle and the neighbor's miniature poodle as poodles, the child has attained a concept of <u>poodle</u> at a beginning classificatory level. At this beginning level children seem to be able to classify, basing their classifications on some of the readily perceptible attributes of the concept; but they cannot give the basis of their classifications.

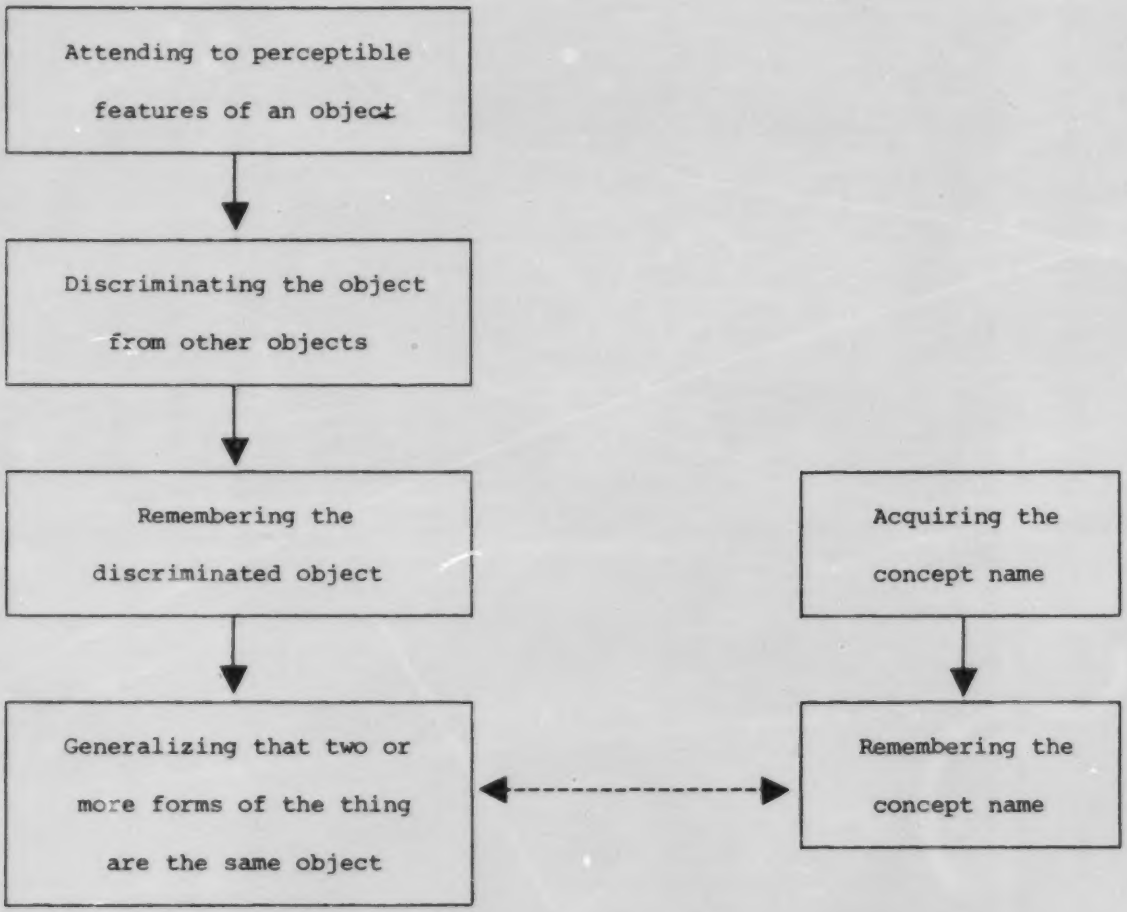
Attending to perceptible features of an object
Discriminating the object from other objects
Remembering the discriminated object
Generalizing that two or more forms of the thing are the same object
Acquiring the concept name
Remembering the concept name

Figure 3. Cognitive operations in concept attainment at the identity level.

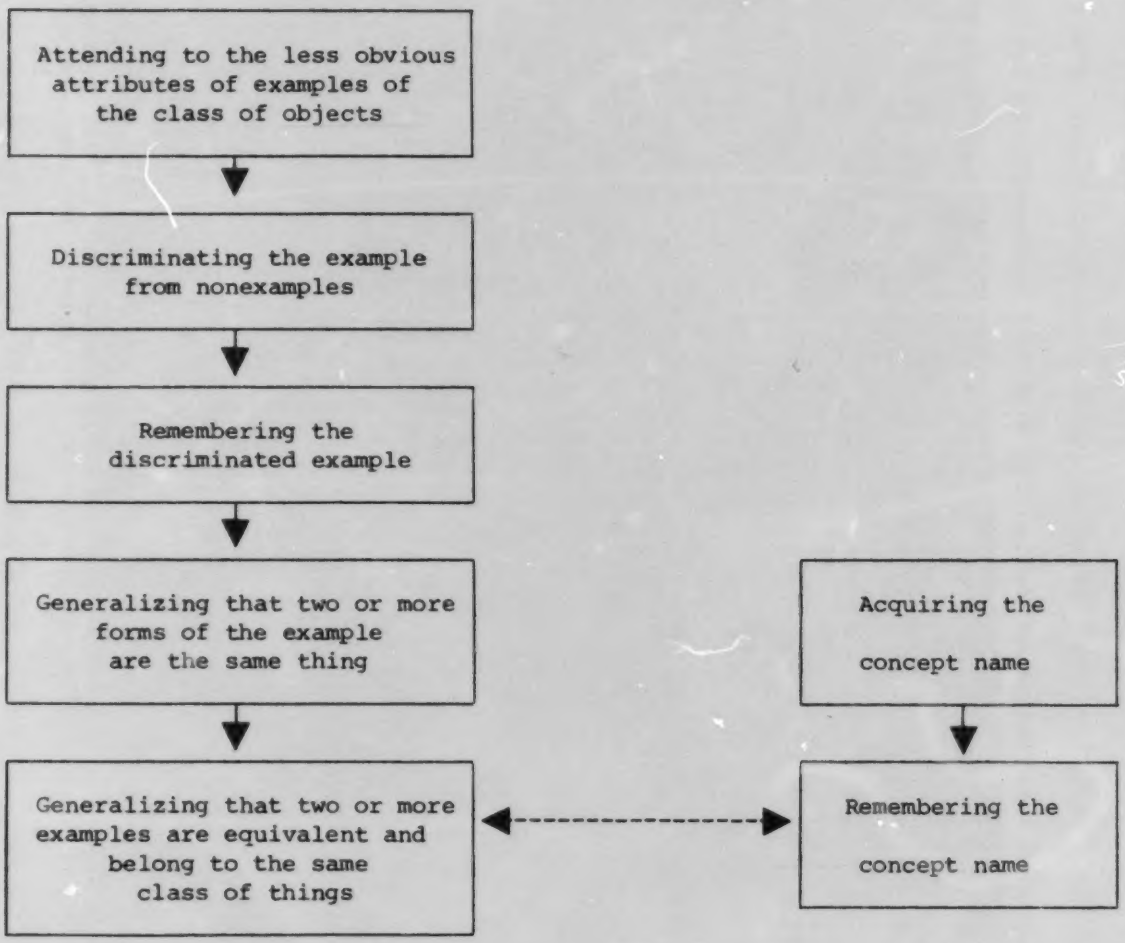
Attending to the less obvious attributes of examples of the class of objects
Discriminating the example from nonexamples
Remembering the discriminated example
Generalizing that two or more forms of the example are the same thing
Generalizing that two or more examples are equivalent and belong to the same class of things
Acquiring the concept name
Remembering the concept name

Figure 4. Cognitive operations in concept attainment at the classificatory level.

It is not clear whether children use global properties or more discrete attributes of concepts at this lowest level of classifying. What is used probably varies according to children's learning styles (Kagan & Kogan, 1970) and also according to the nature of the particular concepts.

Individuals are still at the classificatory level when they can correctly classify a large number of instances as examples and others as nonexamples but they cannot define the word that represents the concept and also cannot explain the basis of their classifying in terms of the defining attributes of the concept. At this higher phase in attaining concepts at the classificatory level, children seem to be able to discriminate some of the less obvious attributes of the concepts and to generalize correctly to a great variety of examples, some of which are very much like some nonexamples. Also they seem to be able to make more explicit than they did earlier the basis of their classifying. In terms of Kofsky's (1966) analysis, included here (from the beginning to the end of the classificatory level) is the following classificatory acquisition sequence of Inhelder and Piaget (1964): consistent sorting, exhaustive sorting, conservation of classes, knowledge of multiple-class membership, horizontal classification, and possibly hierarchical classification.

FORMAL LEVEL

Attainment of a concept at the formal level is inferred when the individual can give the name of the concept, can define the concept in terms of its defining attributes, can discriminate and name its defining attributes, and can evaluate actual or verbally described examples and nonexamples of the particular concept in terms of the presence or absence of the defining attributes. For example, maturing children demonstrate

a concept of tree at the formal level if when shown some examples of trees, shrubs, and herbs, they properly identify the trees and call them "trees"; give a societally accepted definition of tree; discriminate and name the defining attributes of tree; and evaluate how examples of trees differ from examples of shrubs and herbs in terms of the defining attributes of tree. (Many college students cannot do all this without further study, but some high school students who have studied botany can.) When individuals can do these things it may be inferred that they are also capable of performing the cognitive operations for the formal level which are now indicated.

As shown in Figure 5, persons may attain a concept at the formal level inductively or deductively. Whether persons use either of the inductive strategies or the deductive strategy depends on the kind of formal and informal instruction they have experienced, the kind of concept instances that they have experienced, their age, and other factors.

There are two patterns of inductive operations, as portrayed in Figure 6. One pattern involves formulating and evaluating hypotheses regarding the attributes of the concept and the other involves cognizing the attributes that are common to the positive instances. The operations involved in the inductive hypothesis-testing strategy characterize individuals who cognize the information available to them from both examples and nonexamples of the concept. These individuals apparently reason like this: Instance 1 has land totally surrounded by water. It is a member of the class. Instance 2 has land but is only partially surrounded by water. It is not a member of the class. Therefore, lands totally surrounded by

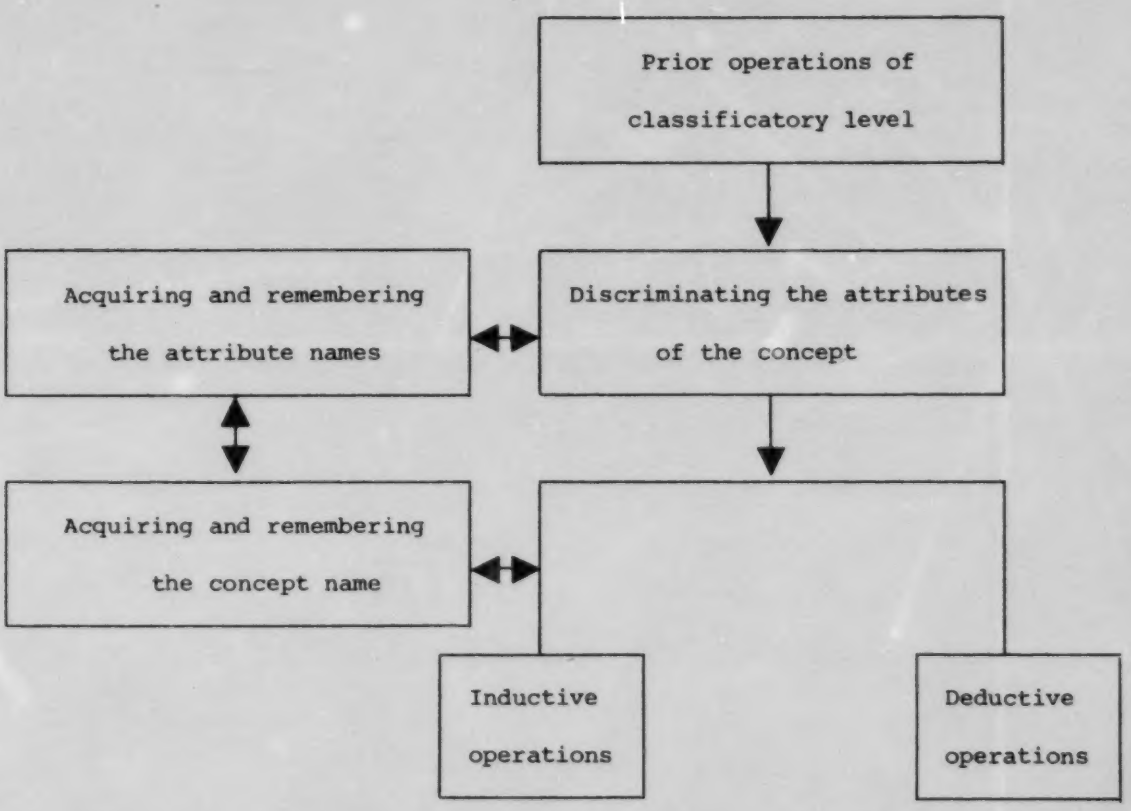
Prior operations of classificatory level
Acquiring and remembering the attribute names
Discriminating the attributes of the concept
Acquiring and remembering the concept name
Inductive operations
Deductive operations

Figure 5. Kinds of operations and strategies of concept attainment at the formal level.

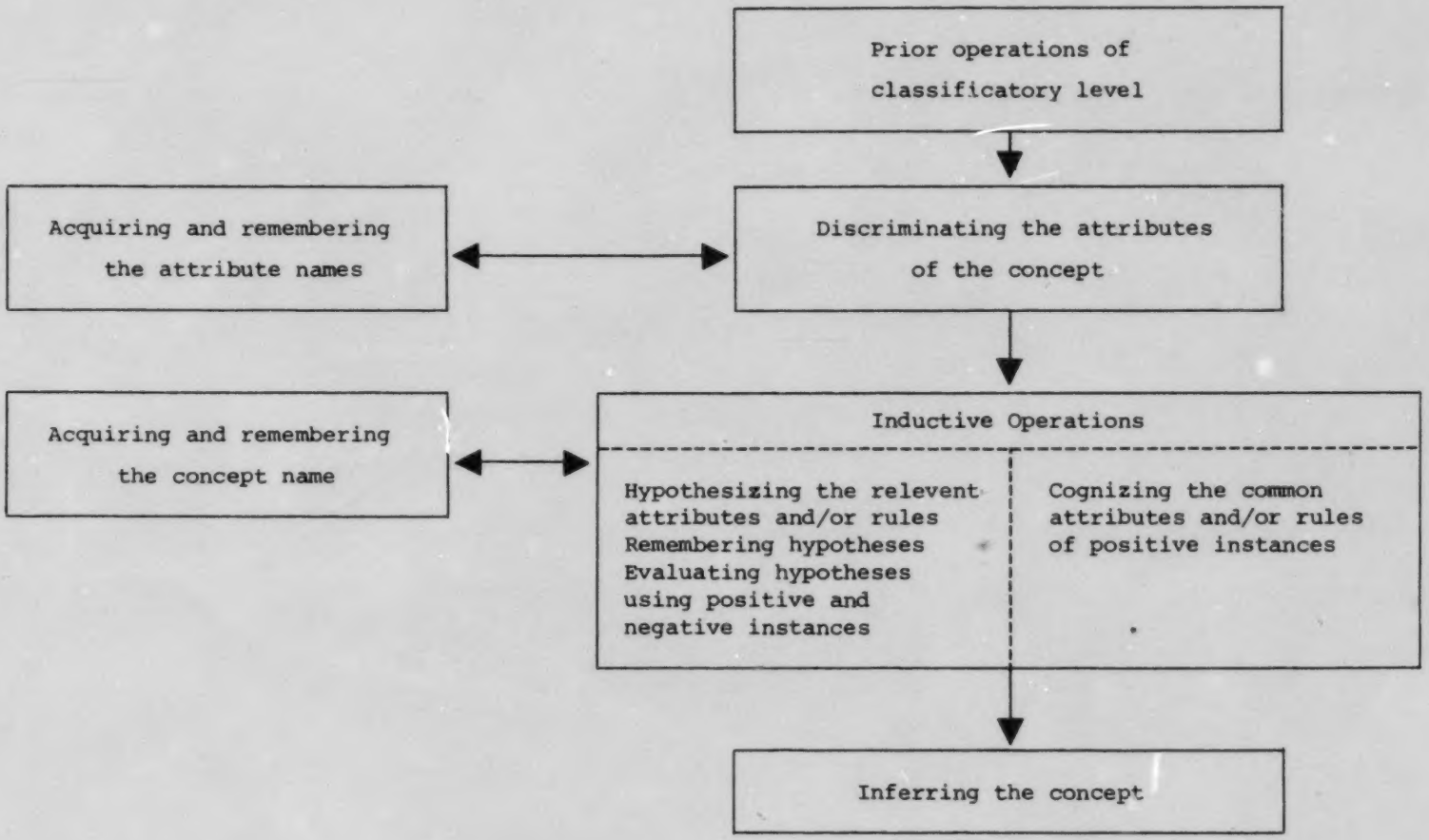
Prior operations of classificatory level
Acquiring and remembering the attribute names
Discriminating the attributes of the concept
Acquiring and remembering the concept name
Inductive Operations
Hypothesizing the relevent attributes and/or rules
Remembering hypotheses
Evaluating hypotheses using positive and negative instances
Cognizing the common attributes and/or rules of positive instances
Inferring the concept

Figure 6. Cognitive operations and inductive strategies of concept attainment at the formal level.

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water belong to the class but lands only partially surrounded by water do not. Totally surrounded by water is one of the defining attributes of the concept. This individual has attained a partial but accurate concept of island based on experiences with only one positive and one negative instance.

A second way of inferring the concept inductively is by identifying the attributes that are common to the examples of the concept. The commonality approach is used more often than the hypothesizing approach by young children apparently because they are either incapable of getting information from nonexamples or they cannot carry out the hypothesizing and evaluating operations (Tagatz, 1967). Further, the commonality strategy is the only one possible when only positive instances of the concept are available to the individual. (Many textbooks give only one example with a verbal definition.)

As shown in Figure 7, concepts may be learned through expository instruction. Learning a concept at the formal level deductively when given all the essential information[1] entails meaningful reception learning as described by Ausubel (1968). Information is thus assimilated, remembered, and then can be used later in identifying examples and nonexamples of the concept. Much concept learning at the formal level by upper elementary, high school, and college students follows this pattern. In this kind of expository instruction, students are given the name of the concept, a verbal definition, verbal examples, and verbal nonexamples but usually no actual instances of the concepts.

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[1] In explaining the formal level earlier, Klausmeier, Ghatala, and Frayer (1974) subsumed the deductive operations under cognizing the common attributes.

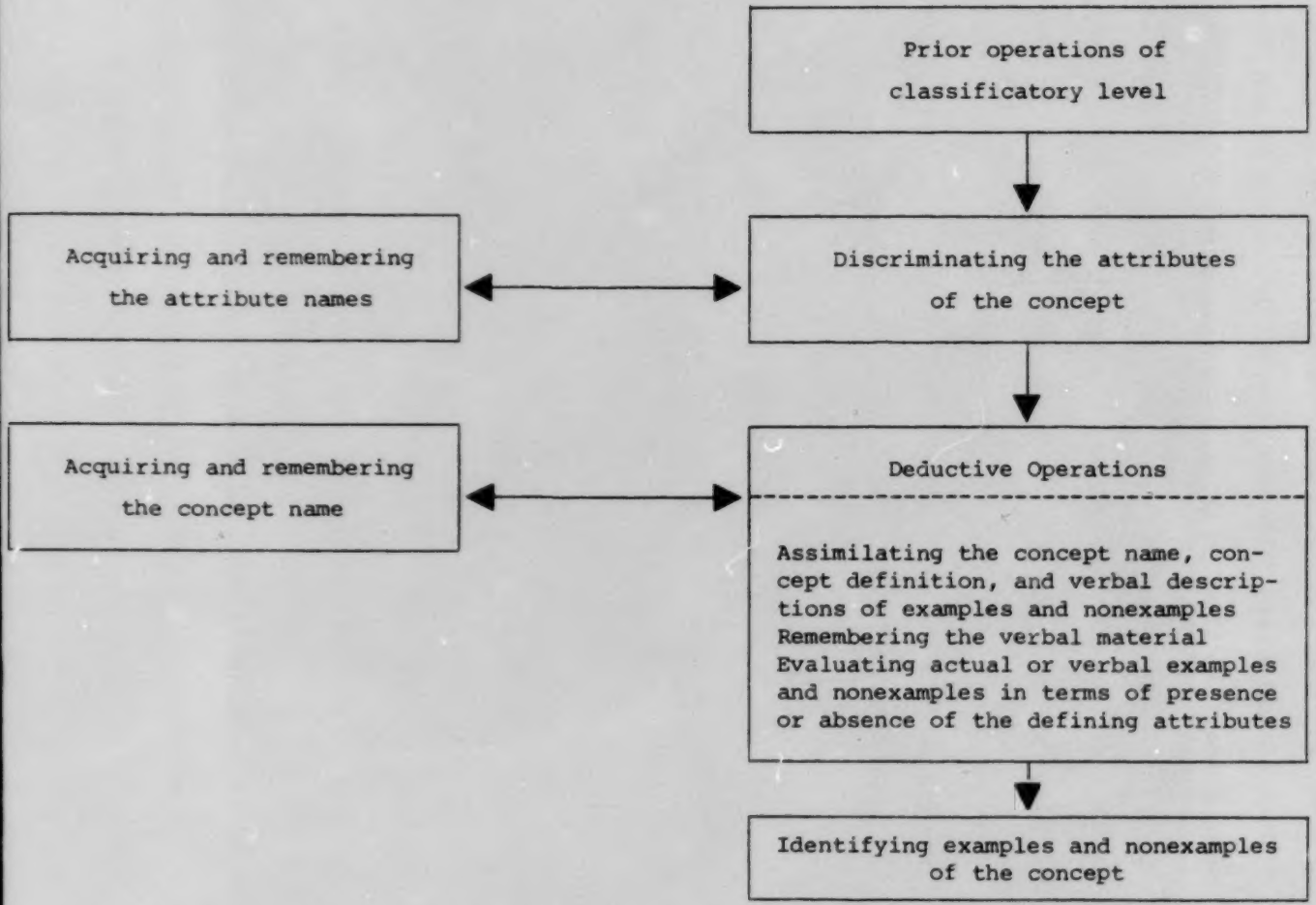
Prior operations of classificatory level
Acquiring and remembering the attribute names
Discriminating the attributes of the concept
Acquiring and remembering the concept name
Deductive Operations
Assimilating the concept name, concept definition, and verbal descriptions of examples and nonexamples
Remembering the verbal material
Evaluating actual or verbal examples and nonexamples in terms of presence or absence of the defining attributes
Identifying examples and nonexamples of the concept

Figure 7. Cognitive operations and deductive strategies of concept attainment at the formal level.

Before leaving this section a few words should be said about acquiring the names of concepts and their attributes. The importance of language in concept learning is widely acknowledged by American (Bruner, 1964) and Russian psychologists (Vygotsky, 1962). Having the labels of concepts enables the individual to think in symbols rather than in images. It also permits more mature individuals to attain some concepts, especially at the formal level, through language experiences in the absence of actual examples or pictorial representations. By the present definition of the formal level the individual must know the defining attributes of the concept and must be able to communicate this knowledge. Verbalizing is normally used in this kind of communication. However, deaf individuals and others who lack speech may attain concepts at the formal level. They use other types of symbolic communication (for example, sign language). Though speech, per se, is not necessary for the attainment of concepts at the formal level, some means for symbolizing and communicating the concept is essential.

Predictions Derived from the Theory

Various predictions may be formulated based on the hypothesized levels of concept attainment and also the uses of attained concepts. The predictions which follow were formulated and provided the basis of the longitudinal investigation. Four predictions follow and the results related to each one as based on cross-sectional studies are indicated.

Prediction 1. Concepts will be attained at four successively higher levels in an invariant sequence. There are five patterns of passing and failing to attain a concept at each of four levels that are consistent

with the principle of an invariant sequence. The five patterns are to: (1) fail all four levels (FFFF); (2) pass the concrete level and fail the next three levels (PFFF); (3) pass the concrete and identity levels but fail the next two levels (PPFF); (4) pass the first three levels but fail the formal level (PPPF); and, finally, (5) pass all four levels (PPPP). There are 11 patterns not in accord with this principle. In these 11 patterns, the student fails an earlier level and then passes a later one (for example, fails the concrete level but passes identity or fails the identity level but passes classificatory). Supporting information for the three concepts for which validated assessment scales were available in the first year of the study indicated that 92 percent of all the children conformed to the five conforming pass-fail patterns for equilateral triangle, 94 percent for cutting tool, and 98 percent for noun. Data on these same three concepts from 1973-74 are presented in Table 1 and indicate slightly higher percentages conforming; data presented for a fourth concept, tree, also show high conformity to the predicted invariant sequence. These very high percentages conforming to the five pass-fail patterns provide the main support for the prediction as stated.

Also supporting this prediction is the finding that the proportion of each successively higher grade group attaining each successive level increased. This conclusion applies to all three concepts as may be inferred from Figures 8, 9, 10, and 11. Information in Figure 8 shows that the percentage of children attaining the concrete level of each of the three concepts increased as a function of the grade group. For example, about 28 percent of kindergarten children, 96 percent of the third-graders, 98 percent of the sixth-graders, and 99 percent of the ninth-graders fully attained the concept noun at the concrete level. This was the most

TABLE 1

PROPORTION OF TOTAL SUBJECT POPULATION CONFORMING TO PREDICTED PASS-FAIL PATTERNS OF ATTAINMENT: COMPARING THE FOUR CONCEPTS

Pass-Fail Sequence	Concept: Equilateral Triangle (N = 351)	Cutting Tool (N = 349)	Noun (N = 362)	Tree (N = 354)
FFFF	.01	.00	.07	.00
PFFF	.01	.00	.12	.01
PPFF	.14	.06	.41	.15
PPPF	.56	.34	.32	.44
PPPP	.25	.57	.08	.37
Total	.97	.97	1.00	.98

Source: Klausmeier, Sipple, and Allen, 1974(b).

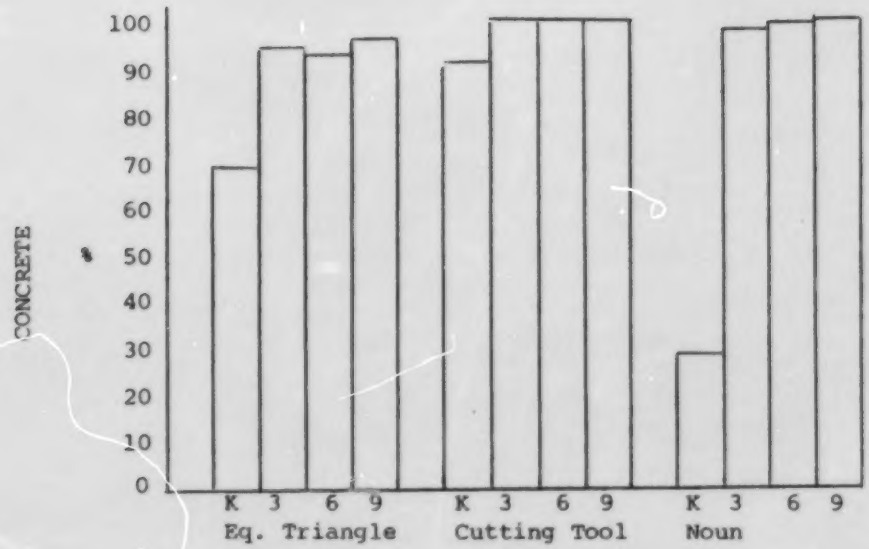

Figure 8. Percent of each grade group fully attaining the concrete level of Equilateral Triangle, Cutting Tool, and Noun. (Source: Klausmeier, Sipple, & Allen, 1974a)

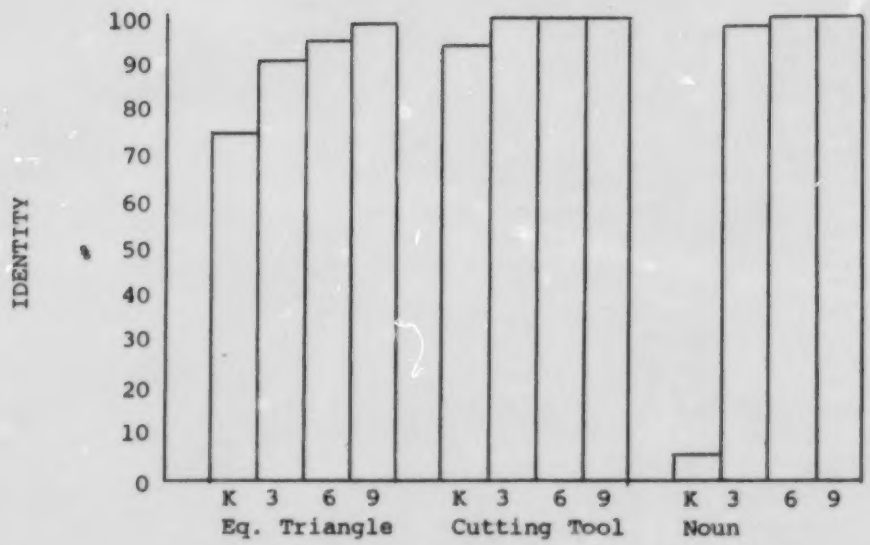

Figure 9. Percent of each grade group fully attaining the identity level of Equilateral Triangle, Cutting Tool, and Noun. (Source: Klausmeier, Sipple, & Allen, 1974a)

difficult of the three concepts at the concrete level, particularly for the kindergarten children. One minor exception to the trend is noted. Slightly fewer sixth-graders than third-graders attained the concrete level of equilateral triangle.

Figure 9 shows the same consistent developmental trend at the identity level of attainment, Figure 10 at the classificatory level, and Figure 11 at the formal level. The developmental trend is obvious at the formal level where no kindergarten children attained equilateral triangle or noun at the formal level, and the spread among the successive grades was quite large and consistent for the three concepts.

The concepts under discussion are drawn from three different subject fields: English, mathematics, and science. Seventy percent or more of the kindergarten children attained the concrete and identity levels of equilateral triangle and cutting tool, the two concepts for which there are actual instances or readily constructed instances in the immediate environment. This suggests that little instruction beyond the kindergarten might be needed at these two levels for this kind of concept. On the other hand, attainment of noun at the formal level was very low by the sixth- and ninth-grade students. The form class, nominals, and the word for the class of things, noun, have been created by man. Although the child early in life says words that are classed as nouns, the words themselves stand for many different kinds of things, ideas, events, etc. This lack of observable examples apparently leads to the difficulty experienced by the children in identifying certain words as nouns and others as not nouns. It is probable that the ninth-graders who did not attain noun at the classificatory or the formal level will never do so unless they receive further instruction.

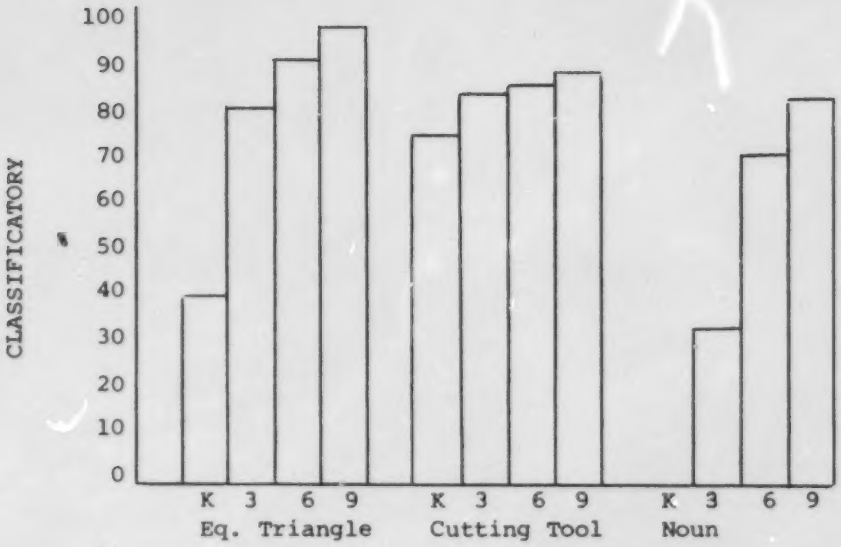

Figure 10. Percent of each grade group fully attaining the classificatory level of Equilateral Triangle, Cutting Tool, and Noun. (Source: Klausmeier, Sipple, & Allen, 1974a)

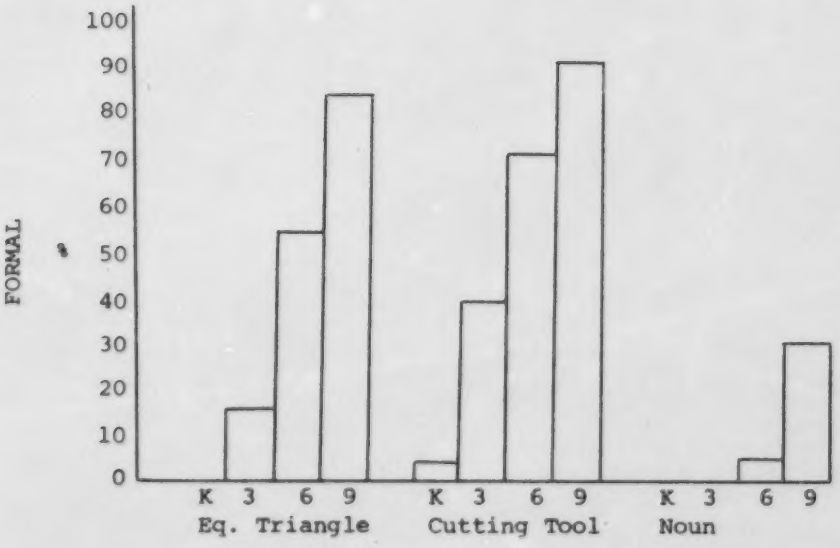

Figure 11. Percent of each grade group fully attaining the formal level of Equilateral Triangle, Cutting Tool, and Noun. (Source: Klausmeier, Sipple, & Allen, 1974a)

They will function throughout their adult lives at a low level of conceptualization with respect to noun (Nelson & Klausmeier, 1974).

Prediction 2. The level of concept attainment will vary among children of the same age. The variability among students of the same grade in the levels of attainment is large as is visually represented in Figure 11 About 17 percent of the third-grade children attained equilateral triangle at the formal level and 83 percent did not; similarly, about 93 percent of the ninth-grade students attained cutting tool at the formal level and about 7 percent did not. It is interesting, too, that some third-graders attained a higher level than did some ninth-graders.

Prediction 3. Various concepts will be attained by the same children at different rates. The first year cross sectional information indicates that attainment of cutting tool at the classificatory and formal levels precedes attainment of equilateral triangle and noun as shown in Figures 10 and 11. In fact, only 30 percent of the ninth-graders had attained noun at the formal level, whereas 90 percent had attained cutting tool at this level. In general, concepts for which there are few or no perceptible instances (e.g., noun) are attained to a certain level (e.g., formal) much later than are other concepts for which there are perceptible instances (e.g., cutting tool).

Prediction 4. Concepts learned at successively higher levels will be used more effectively in understanding supraordinate-subordinate relationships, in understanding principles, and in solving problems. Table 2 shows the percentage of children who attained each of the four levels as their highest performance and who then also passed the three uses. Without

TABLE 2

RELATIONSHIP BETWEEN ATTAINMENT LEVELS AND USES OF EQUILATERAL TRIANGLE, CUTTING TOOL, AND NOUN

	Concrete as Highest			Identity as Highest			Classificatory as Highest			Formal as Highest		
Concept Uses	S-S	Pr	P-S*	S-S	Pr	P-S	S-S	Pr	P-S	S-S	Pr	P-S
Equilateral Triangle	.00	.00	.00	.07	.00	.00	.08	.05	.03	.34	.43	.34
Cutting Tool	.00	.00	.00	.24	.03	.16	.27	.07	.20	.75	.48	.73
Noun	.00	.00	.00	.00	.01	.24	.02	.18	.55	.11	.86	.93

Source: Klausmeier, Sipple, & Allen, 1974(a).

*S-S = Understanding Supraordinate-Subordinate Relations
Pr = Understanding Principles
P-S = Solving Problems

exception, a higher percentage of the students who passed the formal level in comparison with those who passed only the classificatory level performed each of the uses better. Further, the difference in the actual size of the percentages is large. For example, in connection with equilateral triangle the percentages of those who attained the formal level in comparison with those who attained only the classificatory level were as follows: 34 percent and 8 percent for understanding the supraordinate-subordinate relations, 43 percent and 5 percent for understanding the principles, and 34 percent and 3 percent for passing the problem-solving test. There were two minor exceptions to the second conclusion that children who attained a concept to only the concrete or identity level would be able to use the concept only in solving simple perceptual problems.

Also in accord with the prediction, the proportion of children of successively higher-grade groups who mastered each concept increased as shown in Figures 12, 13, and 14. There was only one exception to this finding. Fourteen percent of the third-graders passed the supraordinate-subordinate test for equilateral triangle and only 12 percent of the sixth-graders did. Despite this one minor exception, the increase across grade levels on the various uses for every concept is marked. For example, with respect to understanding supraordinate-subordinate relations involving cutting tool the increase was as follows: kindergarten--8 percent; third grade--43 percent; sixth grade--66 percent; and ninth grade--82 percent.

It is worth emphasizing that assisting students to attain concepts at the formal level is a worthy educational objective, because attainment at this level facilitates understanding relationships among concepts that comprise either a taxonomy or a hierarchy, understanding principles that

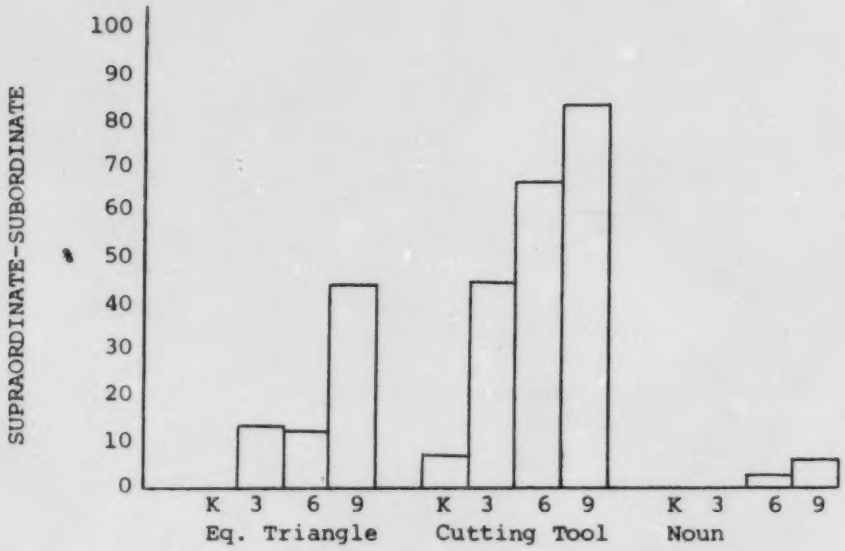

Figure 12. Percent of each grade group fully attaining the supraordinate-subordinate use of Equilateral Triangle, Cutting Tool, and Noun. (Source: Klausmeier, Sipple, & Allen, 1974a)

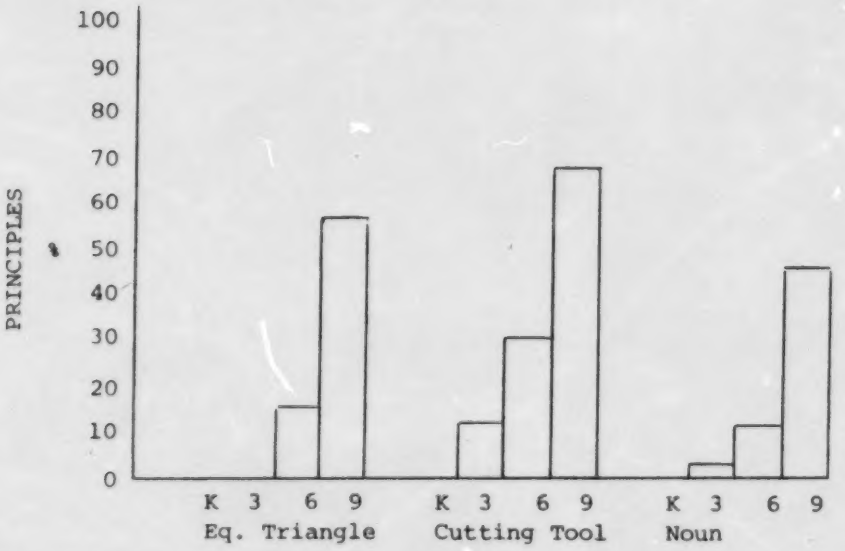

Figure 13. Percent of each grade group fully attaining the principles use of Equilateral Triangle, Cutting Tool, and Noun. (Source: Klausmeier, Sipple, & Allen, 1974a)

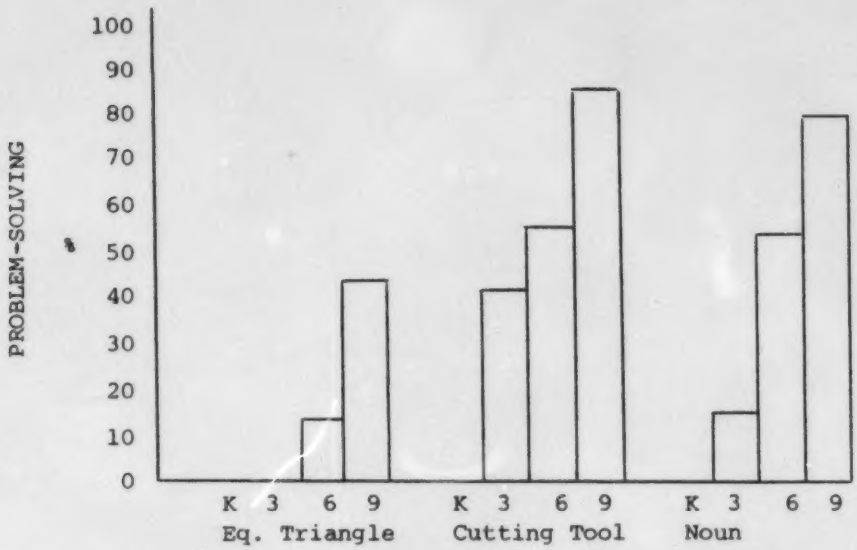

Figure 14. Percent of each grade group fully attaining the problem-solving use of Equilateral Triangle, Cutting Tool, and Noun. (Source: Klausmeier, Sipple, & Allen, 1974a)

involve the particular concept and other concepts, and in solving problems involving the particular concept and/or principles.

It should be noted that instructional conditions can facilitate conceptual development. Since the internal conditions of concept learning vary according to the four levels, instructional conditions must also vary if the instruction is designed to utilize the available capabilities of the learner and to be facilitative of learning. At the classificatory and formal levels, the following conditions have been identified as important in the design of instruction: the proper use of rational sets of examples and nonexamples (Klausmeier & Feldman, 1975; Markle & Tiemann, 1970; Tennyson, Woolley, & Merrill, 1972), the proper matching of the examples and nonexamples (Tennyson, Woolley, & Merrill, 1972), the use of definitions (Feldman & Klausmeier, 1974), the use of cues (Frayer, 1970), and teaching a strategy (McMurray, Bernard, & Klausmeier, 1974). It appears that knowledge about conceptual learning and instruction is sufficiently complete that instructional materials may be designed with precision to teach concepts.

III

OVERVIEW OF PIAGETIAN CONSTRUCTS

It is assumed that the reader has a general familiarity with organismic theory as exemplified in the Piagetian system. Thus, this section will necessarily be brief. Excellent overview sources of the Genevan orientation and associated normative research are available (e.g., Flavell, 1963, 1970; Furth, 1969; Ginsburg & Opper, 1969; Langer, 1969; Piaget, 1950, 1970a, 1970b; Piaget & Inhelder, 1969). Piaget's model of cognitive development is unquestionably the premier structuralist view currently extant. As we have previously stated:

> In direct parallel to biological growth, there are two formal aspects which are assumed in Piagetian theory: organization and adaptation. The former relates directly to structural considerations and demands that any conceptual or empirical analyses acknowledge the total organism/environment system as a fundamental assumption. Adaptation, the sine qua non of cognitive systems in equilibrium, is conceptually "divided" into the functional invariants of assimilation and accommodation. Assimilation (which may be considered as logically and temporally prior to accommodation although it can only arbitrarily be viewed in isolation) is the incorporative aspect of an operative action, i.e., "A taking in of environmental data, not in a causal mechanistic sense, but as a function of an internal structure that by its own nature seeks activity (Furth, 1969, p. 260)." In this manner, incoming stimulation is modified vis-à-vis the individual's current structural makeup. Accommodation, correlatively, is

> the outgoing aspect of an operative process and denotes the modifications that take place in the individual's cognitive makeup as a consequence of environmental intrusions.
>
> These complementary components of organization and adaptive functioning are operationally effective throughout the life-span, thus providing the essential continuity in Piaget's system. In addition, he has posited the concept of vertical *décalage* (which is decidedly similar to Werner's emphasis upon functional analogies, cf. Langer, 1969, pp. 97-98; 1970, pp. 737-738) to describe the major formal correspondences among cognitive achievements and their attendant developmental acquisition patterns at different stages, e.g., object permanence in infancy as analogous to the conservation of invariants during middle childhood. In the Piagetian system the specific contents (subjectively or objectively observed responses) of a particular cognitive event are a joint product of the relatively indeterminant environmental inputs (aliment) and the functional invariants of assimilation and accommodation. Theoretically juxtaposed between these components is the individual's cognitive structure which alters in systematic fashion from birth to maturity (and not incidentally forms the basis for the qualitatively distinctive stage designations) [Hooper & Klausmeier, 1973, pp. 12-13].

There are two primary empirical research questions which derive from the Piagetian structural model, stage sequence and stage correspondence--convergence respectively (cf. Flavell, 1970, 1971; Hooper, 1973; Wohlwill, 1963, 1973). The former research area is not at issue in the present investigation since the focus of the assessment battery was rather exclusively restricted to the period of concrete operational functioning. (It could be maintained, perhaps, that the transition from preoperational to concrete operation's functioning is germane but we view this "sequence" as logically constrained [Flavell, 1972] and therefore of little substantive import.) In contrast, the question of inter-individual and intra-individual performance uniformity and correspondence <u>within</u> a general developmental

period is salient to the present investigation. We are, of course, primarily concerned with the logical concept capacity of the human organism during the years of early and middle childhood. We have previously discussed the nature of concepts as this term is employed by Piagetian scholars, i.e.:

> It would appear that the term concept denotes different entities and associated processes for the Piagetians as contrasted with the typical learning theorist (e.g., Beilin, 1971). The reference point for the term concept varies in Piaget's theory depending upon the general developmental period in question. Thus, in the infant and very young child concepts are denoted by the sensorimotor schemes set in the context of external actions. The gradual appearance of a stable object-permanence concept, that external objects exist independently of the infant's actions upon them or spatiotemporal relationship with them, is an example of a sensorimotor conceptual acquisition.
>
> > In the older preoperational child, concepts are beginning to be interiorized, that is, in part dissociated from particular actions, but yet dominated by personal ("egocentric") viewpoints; in this sense they are "subjective," unstable concepts. Eventually stable "objective" concepts are attained; at the point that they become fully interiorized action schemes--Piaget calls them operations [Furth, Youniss, & Ross, 1970, p. 37].
>
> It is through this action-based operativity that genuine knowledge is acquired. "Operativity, which may involve the use of sensory and perceptual data, leads to the construction of knowledge, while perceptual and sensory data per se do not (Beilin, 1971, p. 99)."
>
> Operativity in the strict sense only becomes possible during the middle childhood years. It is during this time that the child's cognitive activities become organized into coherent and integrated systems. The term operation is used to refer to these systems both as something the child has at his disposal (i.e., activities which the child is capable of performing) and as something the child typically does (Furth, 1969). Concrete operations are internalized representations of coordinated actions

which are, themselves, organized into larger coordinated systems called groupings or *groupements*. Viewed as something the child does, operations include the logico-mathematical activities of adding, subtracting, dividing, setting terms in correspondences as in the cases of classes and relations, and the infralogical activities (anchored to a specific spatiotemporal context) which deal with quantity, measurement, space, and time concepts (cf. Flavell, 1963, p. 166). Viewed as something the child has, operations must be considered as parts of a higher-order structural organization. As Flavell has stated:

> One cannot really grasp the concept of class without understanding what a classification system entails, because the single class is only an abstraction from the total system. This is the central meaning of Piaget's holism in the domain of cognitive operations: the isolated operation can never be the proper unit of analysis, because it gains all its meaning from the system of which it is a part. A given operation, put into concrete effect in the here and now, always presupposes a structured system which includes other, related operations, for the moment latent and inactive but always potentially actualizable themselves and, above all, always a force governing the form and character of the operation which is momentarily on stage [Flavell, 1963, p. 167].

It is these supraordinate structures, the logical operations *groupements*, (Piaget, 1972) which are said to interrelate and subsume all directed thought during the middle childhood period. Four of the *groupements* are concerned with logical classes, and four complementary cases deal with logical relations. The most important of these include primary addition of classes (as evidenced, for example, in the class inclusion problem), bi-univocal multiplication of classes (as shown in matrix completion or class intersection problems), addition of asymmetrical relations (as evidenced in seriation and transitive inference tasks, e.g., the conclusion that A must be less than C, on some dimension, if shown that A<B and B<C), and bi-univocal multiplication of relations (as assessed, for example, in the serial correspondence and double seriation matrix tasks [Hooper & Klausmeier, 1973, pp. 13-15].

According to Piaget, it is the logical *groupements*, which putatively underlie all logical reasoning during the years of middle-childhood, which are the primary focus of the present Piagetian assessment task array. In addition to a newly devised 64-binary choice item test of the 8 logical *groupements* (Brainerd, 1972; Hooper, Brainerd, & Sipple, 1975) representative additional measures of classificatory abilities (dichotomous sorting, some-all understanding, class inclusion, cardinality and combinatorial reasoning), relational abilities (transitive inference, serial ordering and serial correspondence) as well as assessments of the infralogical concept domains dealing with length, and weight conservation (identity and equivalence formats) and the classic number conservation task were selected for inclusion by Hooper. Orthodox Piagetian theory would predict a very low degree of individual variability (within and across subjects) for subjects purportedly located in the stage of concrete operations (Flavell, 1970, 1971; Hooper, 1973; Pinard & Laurendeau, 1969; Wohlwill, 1973). Any significant deviations from this structure synchrony could be accounted for only by the admittedly post hoc construct of horizontal *décalage*.

At the risk of oversimplification, what we are examining is the degree of correspondence between Piaget's unitary logical model of classes and relations and the psychological functioning of representative samples of children across the age range of 5 to 12 years.

IV

PROCEDURES

This chapter provides a description of the sample of children participating in both the CLD assessment series and the series of Piagetian tasks. The two sets of measures are described separately and their technical characteristics reported. Procedures for test administration are then given. Finally, the ways in which the data are treated are outlined.

PARTICIPATING CHILDREN

One hundred and eighty school children enrolled in the Beloit, Wisconsin, public school system participated in the first-year assessments in the spring of 1973. The general subject sampling design for the overall four year duration is presented in Table 3. The children were randomly drawn from kindergarten, third-, and sixth-grade classrooms of four different elementary schools. The schools were selected in accord with the representative socioeconomic, ethnic, and general demographic classifications found in the city of Beloit. Table 4 presents a summary description, according to age and sex, of the 30 boys and 30 girls at each grade who took part in the initial year of the study.[1] The age range of children within each grade varied from 12 to 17 months.

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[1] In addition to these children, 20 boys and 20 girls enrolled in each of the kindergarten, third, and sixth grades, and 50 boys and 50 girls in ninth grade comprised the first year subject sample for the longitudinal study based upon the CLD model.

TABLE 3

SAMPLING DESIGN FOR THE FOUR YEAR LONGITUDINAL RELATIONSHIP STUDY

Year of Birth	Year of Measurement				
	1973	1974	1975	1976	
1967	6(N = 60) [Kindergarten]	7(N = 48)	8	9	(Longitudinal group)
1967		7(N = 24)			(Test effect group)
1967			8		(Test effect group)
1964	9(N = 60) [Third Grade]	10(N = 54)	11	12	(Longitudinal group)
1964		10(N = 24)			(Test effect group)
1964			11		(Test effect group)
1961	12(N = 60) [Sixth Grade]	13(N = 54)	14	15	(Longitudinal group)
1961		13(N = 24)			(Test effect group)
1961			14		(Test effect group)

Note: The entries beneath the Year of Measurement are approximate mean ages in years.

TABLE 4

DISTRIBUTION BY GRADE, SEX, MEAN AGE, AND AGE RANGE OF THE FIRST ASSESSMENT YEAR SUBJECT SAMPLE

Grade	Subjects	Males	Females	Mean Age	Age Range
K	60	30	30	5-10	5-3 to 6-3
3	60	30	30	8- 9	8-3 to 9-8
6	60	30	30	11-10	11-3 to 12-8

TABLE 5

DISTRIBUTION BY GRADE, SEX, MEAN AGE, AND AGE RANGE OF THE SECOND ASSESSMENT YEAR SUBJECT SAMPLE

Grade	Subjects	Males	Females	Mean Age	Age Range
1	48	26	22	6-10	6-3 to 7-3
4	54	26	28	9-10	9-3 to 10-8
7	54	26	28	12-10	12-3 to 13-8

Of the 180 children who took part in the first year of the study, 156 children were available for longitudinal assessment twelve months later in 1974. Attrition was primarily due to entry into parochial schools or moving out of the city. The numbers of children retested in the second year at each grade group--first, fourth, and seventh grades--are given in Table 5. In the second year assessment, the children of the two lower grades were enrolled in 10 different elementary schools. The seventh graders were enrolled in two different junior high schools. Evaluation of the continuing representativeness of the longitudinal subject sample (selective survival biases) and repeated testing effects (longitudinal and testing control sample comparisons, see Table 3) for the initial two years of the present investigation have been reported previously (cf. Hooper, Swinton, & Sipple, 1976; Klausmeier, Allen, Sipple, & White, 1976a, 1976b).

CLD ASSESSMENT SERIES

For the purpose of testing the predictions of the CLD model, scaled batteries to assess the level of cognitive development of children, kindergarten through high school, were constructed for use in the cross sectional/longitudinal study. Four batteries were developed, one battery for each of the following concepts: equilateral triangle from the field of mathematics (Klausmeier, Ingison, Sipple, & Katzenmeyer, 1973a), noun from the field of English language arts (Klausmeier, Ingison, Sipple, & Katzenmeyer, 1973b), tree from the field of science (Klausmeier, Marliave, Katzenmeyer, & Sipple, 1974), and cutting tool, probably related more to science than to other

curriculum areas (Klausmeier, Bernard, Katzenmeyer, & Sipple, 1973). Each battery has seven subtests, one for each of the four levels and one for each of three uses of concepts.

Development of the Batteries

In addition to the usual criteria of reliability, objectivity, and usability, several additional criteria guided development of the batteries. First, the materials and instructions had to permit assessment of subjects of kindergarten through high school age. It was presumed that not all subjects of kindergarten age would attain a given concept at the concrete level and that not all high school subjects would attain it at the formal level. Second, to test for attainment at the concrete, identity, and classificatory levels of the particular concept there had to be perceptible instances or representations thereof. Third, the concept had to have a publicly accepted definition in terms of its properties--functions, relations, or intrinsic attributes--in order to test attainment at the formal level. Fourth, the concept selected for a battery should be relatable to the subject matter which pupils encounter in school. This is in keeping both with the supposition that directed experience, including instruction in school, is a powerful determinant of the particular concepts attained by individuals and also of their level of attainment and use and also with the fact that nearly all children in America attend school from age 5 to 18. Fifth, the particular concept had to be part of a taxonomy in order to test its use in cognizing supraordinate-subordinate relationships. Finally, the concept had to be usable in

cognizing principles and in problem solving. (A concept may be usable in solving simple problems that can be solved on a perceptible basis without being used first in understanding a principle and then in solving more complex problems.)

To develop the tests of concept attainment and utilization, the behaviors involved in attaining the concept were analyzed, and then test items and administrative procedures to assess the behaviors were developed. For each battery, a subtest was developed to assess each of the four levels of concept attainment. Each subtest was constructed specifically to assess the particular operations involved in attaining a concept at each of the four levels.

For each concept battery developed, items within the concrete, identity, and classificatory levels were constructed to be more difficult as nonexamples (a) increased in number and (b) shared more relevant and/or variable attributes with the target examples. A subtest was also developed to ascertain the extent to which a child could use the concept in each of the three ways that have been described. Test items went through expert review by measurement and curriculum area specialists, as well as empirical validation while under development. All subtests in each battery were designed as paper and pencil tasks that could be group administered, except to part of the kindergarten children.

The batteries for the concepts equilateral triangle, tree, and noun are used in the relationship study. The cognitive operations presumed by the CLD model to be both essential and sufficient for attaining each level are restated below and sample items drawn from

the three batteries are presented.[2] Items assessing the three uses of an attained concept are also given.

Operations at concrete level:

Attending to perceptible features of an object

Discriminating the object from other objects

Remembering the discriminated object

Item for concrete level of "tree":

"Look carefully at the drawing."

(Drawing removed for five seconds and brought back. See next page.)

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[2] If items within the successive subtests are more difficult for children, it is because they are less capable of performing the new operation at the given level which is designated with the asterisk and also because the successive levels require that more information must be attended to, discriminated, and remembered. It is noted also that only one of several new operations is measured directly at the formal level, namely, evaluation.

"Put an X on the drawing that looks exactly the same as the one you just saw."

Operations at identity level:

Attending to perceptible features of an object

Discriminating the object from other objects

Remembering the discriminated object

*Generalizing that two or more forms of the thing are the same object

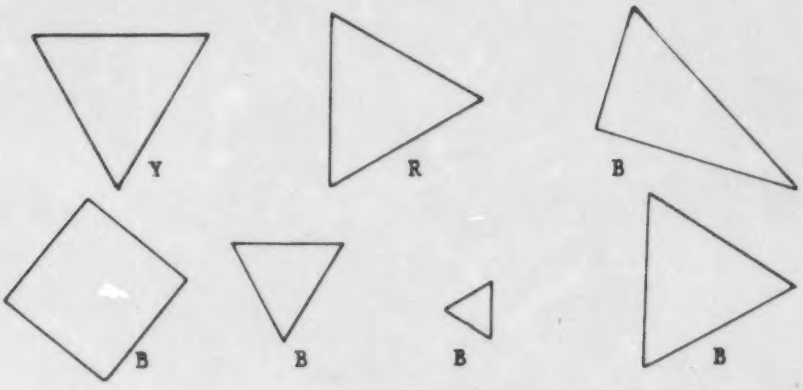
Item for identity level of "equilateral triangle":

"Look carefully at the drawing."

B

(Drawing removed for five seconds and brought back. See next page.)

"Put an X on the drawing that looks exactly the same as the one you just saw."



Key: Y = Yellow
R = Red
B = Blue

Operations at classificatory level:

Attending to the less obvious attributes of examples of the class of objects

Discriminating the example from nonexamples

Remembering the discriminated example

Generalizing that two or more forms of each example are the same thing

*Generalizing that two or more examples are equivalent and belong to the same class of things

Items for classificatory level of "noun":

Put an X on the things below that name one or more persons, places, or things.

tent go rob Dick when

Operations at formal level:

See Figures 5, 6, and 7 of Chapter II.

Item for discriminating the attributes of the concept equilateral triangle:

Below are four drawings. Put an X on the one that has three equal angles.

Item for acquiring the concept name of the concept noun:

Fred mercy children's

Group 1

green together listen

Group 2

What one name best fits all of the words in Group 1 but does not fit all of the words in Group 2?

a. adverbs

b. adjectives

c. verbs

d. nouns

e. I don't know

*Item for evaluating examples and nonexamples of the concept tree in terms of its defining attributes:

Plant X

Plant X is different from all of the other plants in some way. How is it different?

a. Only Plant X has a stem.

b. Only Plant X has roots.

c. Only Plant X has many main stems.

d. Only Plant X has a single main stem.

e. I don't know.

Item for defining the concept equilateral triangle in terms of its defining attributes:

What is the definition of: equilateral triangle?

a. A plane, complex, closed figure with three equal sides.

b. A plane, simple, open figure with three equal sides and three equal angles.

c. A plane, simple, closed figure with three equal sides and three equal angles.

d. A plane, complex, open figure with three equal angles.

e. I don't know.

Item for using the concept tree in understanding supraordinate-subordinate relationships:

Are all of the plants below trees?

a. Yes, all of them are trees.

b. No. only some of them are trees.

c. No, none of them are trees.

d. I don't know.

Item for using the concept equilateral triangle in understanding principles:

"If the angles of a triangle are equal in the number of degrees, _____."

a. one side of the triangle is longer than the other two sides.

b. one side of the triangle is shorter than the other two sides.

c. the sides of the triangle are not equal in length.

d. the sides of the triangle are of equal length.

e. I don't know.

Item for using the concept noun in problem solving:

See the sentence below.

"A _____ ran down the street."

What should be added to complete the sentence above?

a. the word horse used as the subject

b. the word horse used as a predicate

c. the word horse used as an object of a verb

d. the word horse used as a predicate nominative

e. I don't know

Technical Characteristics of the CLD Batteries

Internal consistency for each battery was determined by the use of Hoyt's analysis of variance procedure (algebraically equivalent to Kuder Richardson's formula 20 and Cronback's coefficient alpha). Hoyt reliability coefficients and standard errors of measurement are reported for the larger sample of children administered the CLD batteries in the second assessment year. Therefore, the data are presented for the first-, fourth-, seventh-, and tenth-grade groups which comprise the subject sample for the longitudinal study of children's conceptual learning and development based on the CLD model only. The subscales on which these statistics were computed for each CLD battery are the subtests for each of the four concept levels, the total levels subtests, the subtests for each of three concept uses, and the total uses subtests. Thus, a total of nine subscales

were used and are reported by grade group and across the four grade groups for each concept battery.

Examination of Table 6 reveals that of the 35 Hoyt reliability coefficients reported for the equilateral triangle battery over half are .70 or higher. Table 7 shows that more than half of the 28 Hoyt reliabilities reported for the noun battery are .70 or better. Inspection of Table 8 reveals that of the 35 Hoyt values reported for the tree battery over 60 percent of them are .70 or higher. Many of the lower reliabilities were obtained in cases where subtest means were over 90 percent of the total possible subtest score and standard deviations were very small. Means in this range and low standard deviations indicate an attenuation of the range of obtained scores which precludes higher Hoyt reliabilities being obtained. Although these subtests do not discriminate among the majority of the children in these grade groups, they provide valuable information in that they identify children who may not have attained the corresponding level of conceptual development or facility in concept use. Other low reliabilities were obtained in cases where the associated means and standard deviations were very low, again precluding higher Hoyt reliabilities being obtained. These subtests nonetheless identify children who have attained higher levels of conceptual development or mastered the uses.

The intercorrelation of the total levels score with the total uses score for each concept battery is presented in Table 9 for each of the grade groups and across all the grade groups. The intercorrelation of the scores was not computable for grade group 1, since they

TABLE 6

HOYT RELIABILITY COEFFICIENTS AND STANDARD ERRORS OF MEASUREMENT ON EACH SUBTEST AND ON A COMBINED FORMAL SCORE, TOTAL LEVELS SCORE, AND TOTAL USES SCORE FOR EQUILATERAL TRIANGLE, BY GRADE GROUP AND ACROSS THE FOUR GROUPS FOR THE STANDARDIZATION SAMPLE (SECOND ASSESSMENT YEAR'S RESULTS)

Subtest	Grade Group 1 (n = 82)	4 (n = 92)	7 (n = 91)	10 (n = 86)	All Grades (N = 351)
Concrete (8 items)					
Reliability	.41	NR[a]	NA[b]	NA[b]	.46
SE_M	.43				.28
Identity (8 items)					
Reliability	.32	NR[a]	NA[b]	NA[b]	.26
SE_M	.43				.28
Classificatory (3 items)					
Reliability	.64	.75	.60	.83	.71
SE_M	.42	.28	.27	.20	.30
Combined Formal (18 items)					
Reliability	.50	.60	.72	.81	.83
SE_M	1.74	1.78	1.57	1.33	1.64
Total Levels (37 items)					
Reliability	.57	.59	.71	.80	.83
SE_M	2.00	1.98	1.69	1.48	1.88
Supraordinate-Subordinate Relationships (8 items)					
Reliability	NA[c]	.41	.53	.78	.69[d]
SE_M		1.14	1.14	.92	1.10
Principles (11 items)					
Reliability	NA[c]	.54	.72	.83	.91[d]
SE_M		1.38	1.28	1.00	1.12
Problem-Solving (6 items)					
Reliability	NA[c]	.26	.48	.74	.79[d]
SE_M		.96	.94	.77	.83
Total Uses (25 items)					
Reliability	NA[c]	.61	.75	.91	.93[d]
SE_M		2.15	2.10	1.67	1.91

(See notes a, b, c, d on next page.)

TABLE 6, continued.

NR[a] (Not Reported). Upon examination of the results of the standardized testing, as indicated by the means and standard deviations, it was found that nearly all S's in this grade group passed the subtest. Accordingly, reliability information would be meaningless and is not reported.

NA[b] (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, this subtest was judged to be too easy for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group. All children in this grade group received full credit for this subtest in the computation of the total levels statistic and in the computation of the all grades concrete and identity subtest statistics.

NA[c] (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, this subtest was judged to be too difficult for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group.

d Primary aged children who did not receive this subtest were treated as earning total scores of zero in computing test statistics across grades.

Source: DiLuzio, Katzenmeyer, & Klausmeier, 1975(a).

TABLE 7

HOYT RELIABILITY COEFFICIENTS AND STANDARD ERRORS OF MEASUREMENT ON EACH SUBTEST AND ON A COMBINED FORMAL SCORE, TOTAL LEVELS SCORE, AND TOTAL USES SCORE FOR NOUN, BY GRADE GROUP AND ACROSS THE FOUR GROUPS FOR THE STANDARDIZATION SAMPLE (SECOND ASSESSMENT YEAR'S RESULTS)

	Grade Group				
Subtest	1 (n = 83)	4 (n = 95)	7 (n = 93)	10 (n = 91)	All Grades (N = 362)
Concrete (8 items)					
Reliability	.49	NR[a]	NR[a]	NA[b]	.63
SE_M	.81				.45
Identity (8 items)					
Reliability	.67	NR[a]	NR[a]	NA[b]	.85
SE_M	1.01				.59
Classificatory (8 items)					
Reliability	NR[c]	.64	.71	.77	.91
SE_M		1.04	.87	.73	.85
Combined Formal (25 items)					
Reliability	NR[c]	.49	.78	.82	.92
SE_M		2.06	2.07	2.03	1.87
Total Levels (49 items)					
Reliability	NR[c]	.64	.80	.84	.95
SE_M		2.43	2.38	2.29	2.38
Supraordinate-Subordinate Relationships (8 items)					
Reliability	NA[d]	NR[c]	.44	.57	.78[e]
SE_M			1.07	1.04	.99
Principles (10 items)					
Reliability	NA[d]	NR[c]	.59	.60	.83[e]
SE_M			1.32	1.25	1.15
Problem Solving (5 items)					
Reliability	NA[d]	NR[c]	.39	.58	.67[e]
SE_M			.86	.82	.75
Total Uses (23 items)					
Reliability	NA[d]	NR[c]	.71	.78	.91[e]
SE_M			2.02	1.93	1.78

(See notes a, b, c, d, e on next page.)

TABLE 7, continued.

NR[a] (Not Reported). Upon examination of the results of the standardized testing, as indicated by the means and standard deviations, it was found that nearly all S's in this grade group passed the subtest. Accordingly, reliability information would be meaningless and is not reported.

NA[b] (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, this subtest was judged to be too easy for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group. All children in this grade group received full credit for this subtest in the computation of the total levels statistic and in the computation of the combined grades concrete and identity subtest statistics.

NR[c] (Not Reported). Upon examination of the results of the standardized testing, as indicated by the means and standard deviations, this subtest was found to be too difficult for use with this grade group. Accordingly, reliability information would be meaningless and is not reported.

NA[d] (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, this subtest was judged to be too difficult for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group.

[e] Primary aged children who did not receive this subtest were treated as earning total scores of zero in computing test statistics across grades.

Source: DiLuzio, Katzenmeyer, & Klausmeier, 1975(b).

TABLE 8

HOYT RELIABILITY COEFFICIENTS AND STANDARD ERRORS OF MEASUREMENT ON EACH SUBTEST AND ON A COMBINED FORMAL SCORE, TOTAL LEVELS SCORE, AND TOTAL USES SCORE FOR TREE, BY GRADE GROUP AND ACROSS THE FOUR GROUPS FOR THE STANDARDIZATION SAMPLE (SECOND ASSESSMENT YEAR'S RESULTS)

	Grade Group				
Subtest	1 (n = 83)	4 (n = 93)	7 (n = 91)	10 (n = 87)	All Grades (N = 354)
Concrete (8 items)					
Reliability	.08	NR[a]	NA[b]	NA[b]	.16
SE_M	.47				.29
Identity (8 items)					
Reliability	.06	NR[a]	NA[b]	NA[b]	.15
SE_M	.57				.36
Classificatory (8 items)					
Reliability	.81	.81	.88	.76	.84
SE_M	.89	.57	.55	.43	.63
Combined Formal (35 items)					
Reliability	.76	.78	.86	.78	.91
SE_M	1.96	2.27	2.00	1.68	2.10
Total Levels (59 items)					
Reliability	.78	.79	.89	.80	.92
SE_M	2.42	2.50	2.18	1.79	2.39
Supraordinate-Subordinate Relationships (8 items)					
Reliability	NA[c]	.28	.49	.62	.72[d]
SE_M		1.03	1.03	.90	1.01
Principles (20 items)					
Reliability	NA[c]	.70	.77	.83	.93[d]
SE_M		1.89	1.84	1.57	1.62
Problem Solving (10 items)					
Reliability	NA[c]	.38	.51	.61	.67[d]
SE_M		1.21	1.30	1.30	1.24
Total Uses (38 items)					
Reliability	NA[c]	.67	.84	.88	.94[d]
SE_M		2.58	2.55	2.31	2.38

(See notes a, b, c, d on next page.)

TABLE 8, continued.

NR[a] (Not Reported). Upon examination of the results of the standardized testing, as indicated by the means and standard deviations, it was found that nearly all S's in this grade group passed the subtest. Accordingly, reliability information would be meaningless and is not reported.

NA[b] (Not Administered). On the basis of test results obtained in the tryout of the battery, this subtest was judged to be too easy for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group. All children in this grade group received full credit for this subtest in the computation of the total levels statistic and in the computation of the combined grades concrete and identity subtest statistics.

NA[c] (Not Administered). On the basis of test results obtained in the tryout of the battery, this subtest was judged to be too difficult for use with this grade group. Thus, when the final edition was administered this subtest was not included for this grade group.

[d] Primary aged children who did not receive this subtest were treated as earning total scores of zero in computing test statistics across grades.

Source: DiLuzio, Katzenmeyer, & Klausmeier, 1975(c).

TABLE 9

INTERCORRELATION OF THE TOTAL LEVELS SCORE AND THE TOTAL USES SCORE, BY GRADE GROUP AND ACROSS GRADE GROUPS FOR EACH OF CLD BATTERIES: EQUILATERAL TRIANGLE, NOUN, AND TREE

Grade Group	Correlation		
	Equilateral Triangle	Noun	Tree
1	(n = 82) NA[a]	(n = 83) NA[a]	(n = 83) NA[a]
4	(n = 92) .44	(n = 95) .45	(n = 93) .47
7	(n = 91) .51	(n = 93) .68	(n = 91) .80
10	(n = 86) .73	(n = 91) .81	(n = 87) .59
Combined Grade Groups	(n = 351) .80	(n = 362) .90[b]	(n = 354) .84[b]

NA[a] (Not Administered). On the basis of test results obtained with the preliminary edition of the battery, all of the uses subtests were judged to be too difficult for use with first-grade children. Thus, when the final edition was administered these subtests were not included for this grade group.

[b] Primary aged children who did not receive the uses subtests were treated as earning total scores of zero on total uses for the purposes of this correlation.

Source: DiLuzio, Katzenmeyer, & Klausmeier, 1975(a), (b), and (c).

did not receive all items of the uses subtests. The range of correlations within each grade group is .44 to .81; the intercorrelations of the scores when all grade groups are combined ranged from .80 to .90. These intercorrelations give support to the assumption that concept utilization is positively related to concept attainment.

Administration of the CLD batteries. The paper-and-pencil batteries were administered by trained personnel from the Wisconsin Research and Development Center for Cognitive Learning according to the instructions specified in the Development of Conceptual Learning and Development Assessment Series I: Equilateral Triangle (Klausmeier, Ingison, Sipple, & Katzenmeyer, 1973), the Development of Conceptual Learning and Development Assessment Series III: Noun (Klausmeier, Ingison, Sipple, & Katzenmeyer, 1973), and the Development of Conceptual Learning and Development Assessment Series IV: Tree (Klausmeier, Marliave, Katzenmeyer, & Sipple, 1974). A set of guidelines was used in developing the directions for test administration and item formats. The purpose of these guidelines was to ensure that valid responses could be obtained from children of all ages. First, "practice" questions would be offered. Second, specific repetitions of instructions or questions would be prescribed for use with younger children to ensure that they fully grasped the nature of the task. Third, all items would be read aloud by the test administrator since reading ability was not the specific measurement objective. Fourth, attractive item formats would be used to engage the interest of the children. Fifth, all stimulus and response materials would be arranged in a

left-to-right flow. Sixth, items and pages would be designed so that children could easily keep their places.

Instructions for administering specific subtests were developed on the basis of information gathered from the tryout of items on a small sample of children, criticisms and suggestions of test specialists, and suggestions of personnel who administered the test. The main criteria for these directions were clarity and usability.

The batteries are intended for use with children of ages 4 to 18, and were standardized on children at four grade levels: 1, 4, 7, and 10. The span of age represented in the standardization sample provides sufficient information to examine the usability of each subtest for children of various ages. Two forms of the test were developed, primary and intermediate. Items used in the primary form are a subset of those used in the intermediate form. In addition, a simplified set of directions is used with the primary form.

In the process of test development, certain subtests were found to be too difficult or too easy for children in some grades. Tables 10, 11, and 12 present the set of subtests found to be most appropriate for administration at each of the four grade levels included in the standardization sample, as well as the number of items per subtest and average amount of time needed to administer each subtest for each form.

For grades 3 and above, the batteries were administered to groups of about 20 to 30 children, while for kindergarten (first year assessment) and first grade (second year assessment) the batteries were

TABLE 10

APPROPRIATENESS AND AVERAGE ADMINISTRATION TIME OF ITEMS OF THE VARIOUS SUBTESTS OF THE CONCEPTUAL LEARNING AND DEVELOPMENT ASSESSMENT SERIES I: EQUILATERAL TRIANGLE FOR CHILDREN IN DIFFERENT GRADE GROUPS OF THE STANDARDIZATION SAMPLE

	Number of Items				Average Administration Time in Minutes			
	Primary Form	Intermediate Form			Primary Form	Intermediate Form		
Subtest	Grade 1	Grade 4	Grade 7	Grade 10	Grade 1	Grade 4	Grade 7	Grade 10
Concrete Level	8	NA	NA	NA	5	NA	NA	NA
Identity Level	8	NA	NA	NA				
Classificatory Level	3	3	3	3	3-5	3	3	3
Evaluating and Defining	5	6	6	6	6	6	6	6
Naming	6	7	7	7	8	8	8	8
Discriminating Attributes	5	5	5	5	3	2	2	2
Supraordinate-Subordinate Relationships	NA	8	8	8	NA	5	5	5
Principles	NA	11	11	11	NA	8	8	8
Problem-Solving	NA	6	6	6	NA	7	7	7
Total Battery	35	46	46	46	27	39	39	39

NA = Not appropriate for these grade groups.

TABLE 11

APPROPRIATENESS AND AVERAGE ADMINISTRATION TIME OF ITEMS OF THE VARIOUS SUBTESTS OF THE CONCEPTUAL LEARNING AND DEVELOPMENT ASSESSMENT SERIES III: NOUN FOR CHILDREN IN DIFFERENT GRADE GROUPS OF THE STANDARDIZATION SAMPLE

	Number of Items				Average Administration Time in Minutes			
	Primary Form	Intermediate Form			Primary Form	Intermediate Form		
Subtest	Grade 1	Grade 4	Grade 7	Grade 10	Grade 1	Grade 4	Grade 7	Grade 10
Concrete Level	8	NA	NA	NA	5	NA	NA	NA
Identity Level	8	NA	NA	NA				
Classificatory Level	NA	8	8	8	NA	7	7	7
Evaluating and Defining	NA	9	9	9	NA	10	10	10
Naming	NA	9	9	9	NA	10	10	10
Discriminating Attributes	NA	7	7	7	NA	7	7	7
Supraordinate-Subordinate Relationships	NA	NA	8	8	NA	NA	10	10
Principles	NA	NA	10	10	NA	NA	10	10
Problem-Solving	NA	NA	5	5	NA	NA	5	5
Total Battery	16	33	56	56	5	34	59	59

NA = Not appropriate for these grade groups.

TABLE 12

APPROPRIATENESS AND AVERAGE ADMINISTRATION TIME OF ITEMS OF THE VARIOUS SUBTESTS OF THE CONCEPTUAL LEARNING AND DEVELOPMENT ASSESSMENT SERIES IV: TREE FOR CHILDREN IN DIFFERENT GRADE GROUPS OF THE STANDARDIZATION SAMPLE

	Number of Items				Average Administration Time in Minutes			
	Primary Form	Intermediate Form			Primary Form	Intermediate Form		
Subtest	Grade 1	Grade 4	Grade 7	Grade 10	Grade 1	Grade 4	Grade 7	Grade 10
Concrete Level	8	NA	NA	NA	5	NA	NA	NA
Identity Level	8	NA	NA	NA				
Classificatory Level	8	8	8	8	5	5	5	5
Evaluating and Defining	10	11	11	11	12	10	10	10
Naming	11	14	14	14	10	10	10	10
Discriminating Attributes	10	10	10	10	5	5	5	5
Supraordinate-Subordinate Relationships	NA	8	8	8	NA	5	5	5
Principles	NA	20	20	20	NA	10	10	10
Problem-Solving	NA	10	10	10	NA	10	10	10
Total Battery	55	81	81	81	37	55	55	55

NA = Not appropriate for these grade groups.

administered to smaller groups of five to seven children. The subtests were read to children regardless of grade level. Children marked their answers directly on the test booklet pages; separate answer sheets were not used.

Treatment of CLD data. An important use of the CLD batteries is in the placement of individual children on the continuum of conceptual development with respect to the particular concepts being assessed. For some applications it is desirable to reduce this information to the single datum of the level at which the child is performing. To facilitate this placement, a scoring scheme was developed to indicate mastery versus nonmastery of each of the concrete level, identity level, classificatory level, and formal level subtests; that is, results were treated as dichotomous data. All items were given equal weight, and full attainment of a level was indicated by a score greater than or equal to a predefined criterion score on the corresponding subtest. These criteria are presented in Table 13. Also, specific criteria set for each uses subtest determined passing, or attainment of each use and are presented in Table 13.

Correlational results between performances on CLD tasks and Piagetian tasks reported in Chapters 5 and 6 as well as results of factor analysis were based upon the total number of items correct on the four levels of each CLD battery as well as the total number of items correct on each uses subtest; that is, results were also treated as interval data.

TABLE 13

NUMBER OF ITEMS AND CRITERIA DEFINING FULL ATTAINMENT FOR EACH LEVEL AND USE OF THE CLD BATTERIES

Subtest	Equilateral Triangle		Noun		Tree	
	Number of Items	Criteria for Full Attainment	Number of Items	Criteria for Full Attainment	Number of Items	Criteria for Full Attainment
Concrete	8	7	8	7	8	7
Identity	8	7	8	7	8	7
Classificatory	3	3	8	7	8	7
Formal						
Discrim. Attributes	5	15 items correct or approximately 80% of Formal items[1]	7	20 items correct or approximately 80% of Formal items	10	28 items correct or approximately 80% of Formal items
Labels	7		9		14	
Evaluating Defining Attributes	5		8		10	
Definition	1		1		1	
Principle	5 pairs	4 pairs	5 pairs	4 pairs	10 pairs	8 pairs
Problem Solving	5	4	5	4	10	8
Supraordinate-Subordinate	4 pairs	3 pairs	4 pairs	3 pairs	4 pairs	3 pairs

[1] In the first year of the study, the formal level subtest of the equilateral triangle battery included only 3 discriminating attributes items, and 7 labels items. Criterion for full attainment of this level was passing the 3 discriminating items and at least 5 of the 7 labels items.

PIAGETIAN TASK SERIES

Development of the Piagetian Tasks

A series of measures was designed by Brainerd (1972) to assess the logical *groupements* associated with the concrete operations period of middle-childhood. The eight *groupement* tasks are: I, primary addition of classes; II, secondary addition of classes; III, bi-univocal multiplication of classes; IV, co-univocal multiplication of classes; V, addition of asymmetrical relations; VI, addition of symmetrical relations, VII, bi-univocal multiplication of relations; and VIII, co-univocal multiplication of relations. Sixty-four binary choice items were devised; one-half of these assess the operation of logical composition while the remainder assess the inverse operation (class cases) and reciprocal operation (relations cases). In addition, complimentary concrete operations tasks were adapted from the procedures of previous normative investigations. These include dichotomous sorting, some-all relationships, class inclusion, cardinality, serial (a) construction, (b) addition, (c) matching, (d) extension and compression, (e) scrambled case, transitivity of length, transitivity of weight, and conservation of length, of weight, and of number. A measure of combinatorial reasoning, associated with the formal operations period, was also adapted. Finally, an arithmetic computation task and three memory measures were selected: auditory memory span [word series], auditory sequential memory [digit span], and visual orientation memory. Brief descriptions of the administration procedures and stimulus materials

employed in each of the concrete operations tasks are presented below. For complete administration procedures and associated scoring protocols see A Representative Series of Piagetian Concrete Operations Tasks (Hooper, Brainerd, & Sipple, 1975).

Groupement I: Primary Addition of Classes

Operations: A. Composition (addition) of primary classes A (triangles with yellow) + A' (triangles without yellow) = B (triangles)

Questions: 1. Are there the same number of triangles with yellow on them as there are triangles?

2. Are there more triangles than there are triangles with yellow on them?

B. Inversion (subtraction) of primary classes B (triangles) - A (triangles with yellow) = A' (triangles without yellow)

Questions: 3. If I took away the triangles with yellow on them would there be some triangles left?

4. If I took away the triangles with yellow on them would all the triangles be gone?

Stimulus Materials: See Figure 15 for stimuli.

Four questions comparable to questions 1 through 4 using circular stimuli are also included.

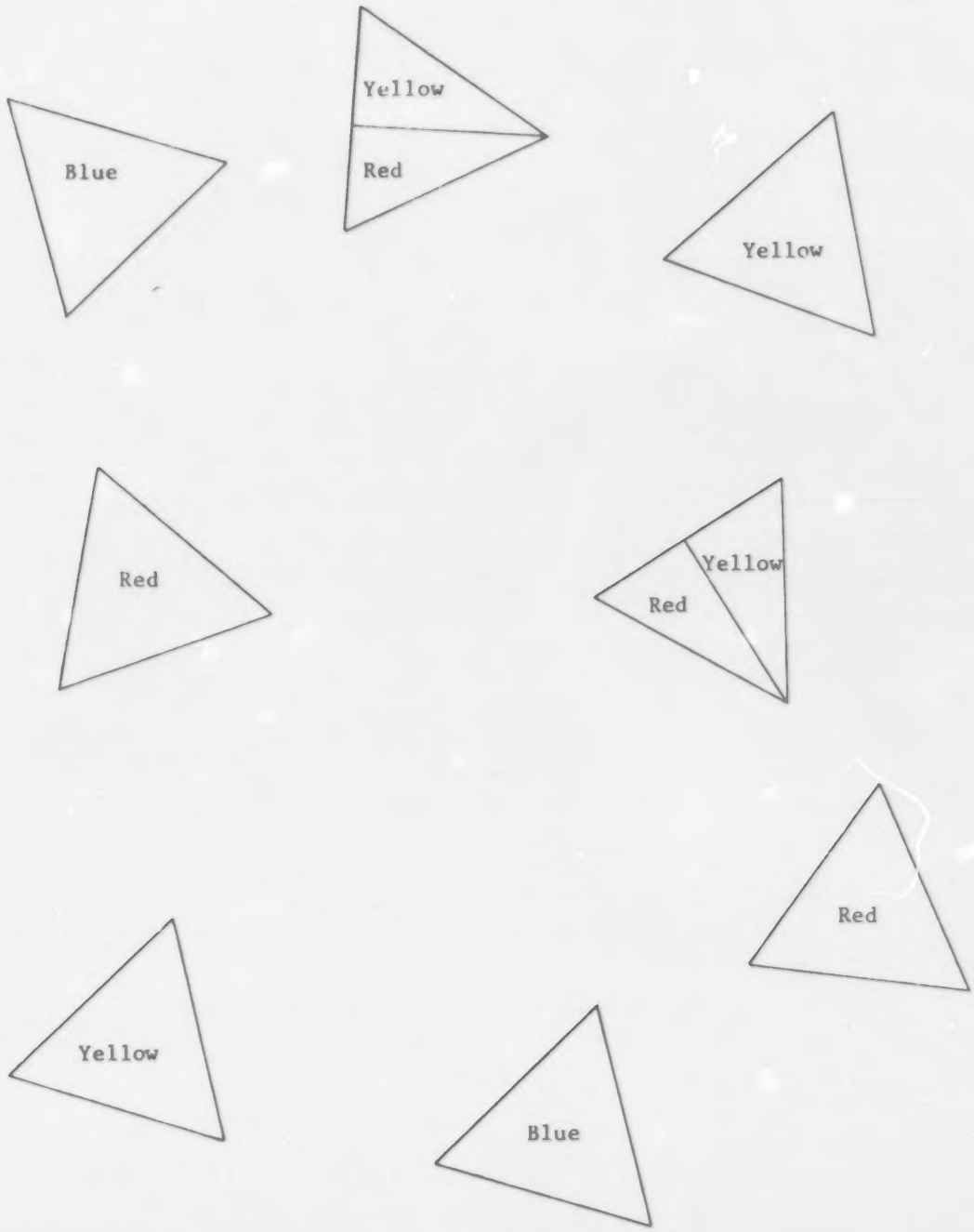


Figure 15. Stimuli for *Groupements* I, II, and III.

(For *Groupement* I, preliminary counting is carried out to establish that there are 4 triangles that have some yellow on them and 4 triangles that do not have yellow on them. For *Groupement* II, preliminary counting is carried out to establish that there are 4 triangles that have some red on them and 4 triangles that do not have red on them. For *Groupement* III, preliminary counting is carried out to establish that there are 4 triangles that have some red on them and 4 triangles that have some yellow on them.)

Groupement II: Secondary Addition of Classes

Operations: A. Composition (addition) of secondary classes A_2 (triangles with red) + A_2' (triangles without red) = B (triangles)

Questions: 1. Are there the same number of triangles with red on them as there are triangles?

2. Are there more triangles than there are triangles with red on them?

B. Inversion (subtraction) of secondary classes B (triangles) - A_2 (triangles with red) = A_2' (triangles without red)

Questions: 3. If I took away the triangles with red on them, would there be some triangles left?

4. If I took away the triangles with red on them, would all the triangles be gone?

Stimulus Materials: Same triangles as used in *Groupement* I. See Figure 15.

Four questions comparable to questions 1 through 4 using circular stimuli are also included.

Groupement III: Bi-univocal Multiplication of Classes

Operations: A. One-to-one composition (multiplication) of classes A_1 (triangles with yellow) x A_2 (triangles with red) = A_1A_2 (triangles with both yellow and red)

Questions: 1. Are there the same number of triangles with yellow on them as there are triangles with both red and yellow on them?

2. Are there more triangles with yellow on them than there are triangles with both red and yellow on them?

B. Inversion (division) of a product class by one class A_1A_2 (triangles with both yellow and red) ÷ A_1 (triangles with yellow) = A_2 (triangles with red)

Questions: 3. If I took away the triangles with yellow on them would there be any triangles with both red and yellow on them left?

4. If I took away the triangles with yellow on them, would all the triangles with both red and yellow on them be gone?

Stimulus Materials: Same triangles as used in *Groupements* I and II. See Figure 15.

Four questions comparable to questions 1 through 4 using circular stimuli are also included.

Groupement IV: Co-univocal Multiplication of Classes

Operations: A. One-to-many composition (multiplication) of classes K_1 [triangles (A_1 = red, B_1 = yellow)] x K_2 [yellow (A_2 = triangles, A_2' = circles)] = A_1A_2 (red triangles) + B_1A_2 (yellow triangles) + B_1A_2' (yellow circles)

Questions: 1. Are there the same number of yellow triangles as yellow things?

2. Are there more yellow things than yellow triangles?

B. Inversion (division) of product classes by one class [A_1A_2 (red triangles) + B_1A_2 (yellow triangles) + B_1A_2' (yellow circles)] ÷ [B_1 (yellow) + A_2 (triangles) + A_2' (circles)] = A_1 (red).

Questions: 3. If I took away the yellow things, would there be any yellow triangles left?

4. If I took away the yellow things, would all the yellow triangles be gone?

Stimulus Materials: See Figure 16 for stimuli.

Four questions comparable to questions 1 through 4 using an alternate set of geometric figures are also included.

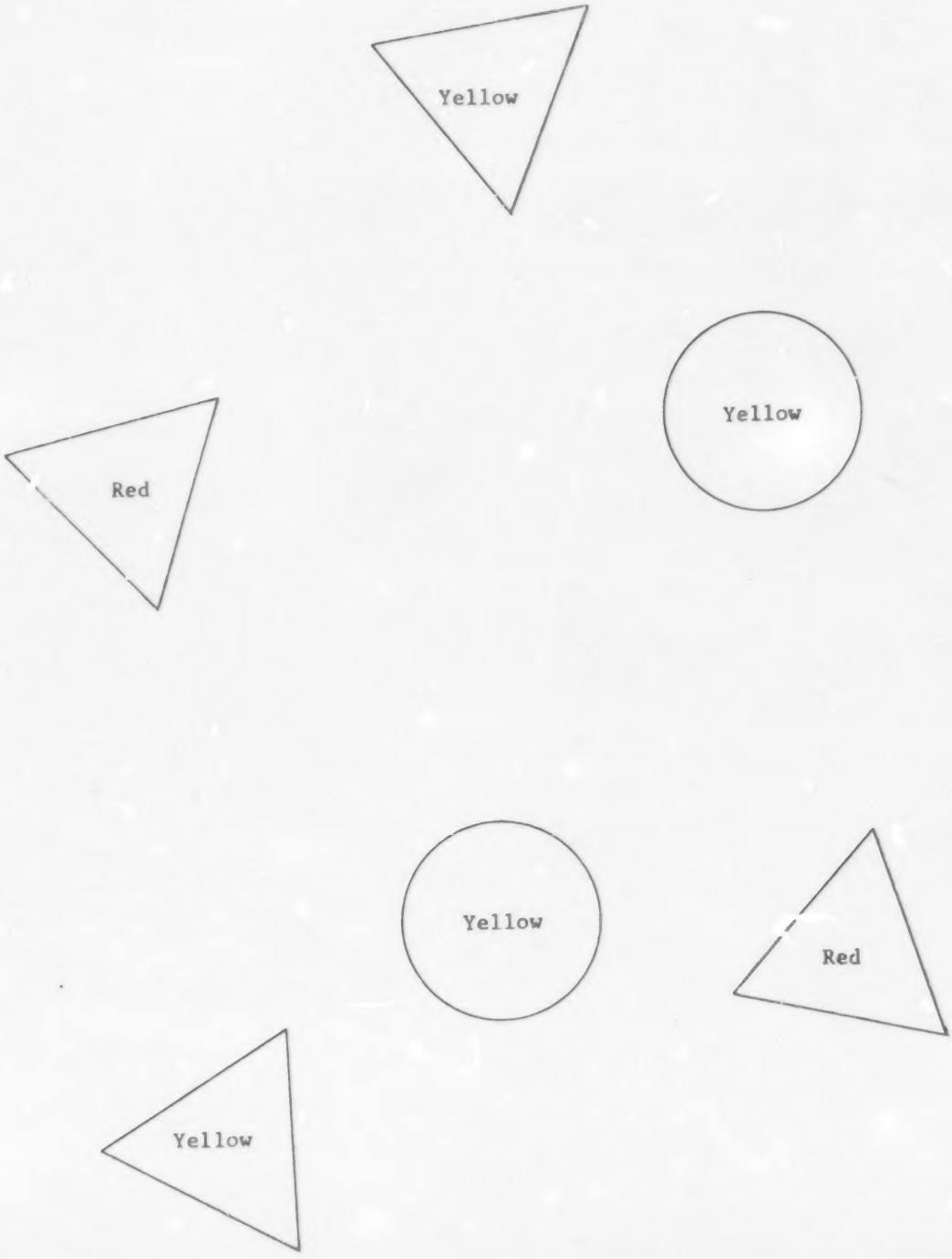


Figure 16. Stimuli for *Groupement* IV.

(For *Groupement* IV, preliminary counting is carried out to establish that there are 4 yellow things and 2 triangles.)

Groupement V: Addition of Asymmetrical Relations

Operations: A. Composition (addition) of difference relations

[(A ← B) + (B ← C) = (A ← C)]

Questions: 1. Are the blue and red sticks the same length?

2. Is the blue stick shorter than the red stick?

B. Reciprocity of difference relations [(A ← B) + (B ← C) = (A ← C)] + [(C → B) + (B → A) = (C → A)] = (A = A)

Questions: 3. Are the red and blue sticks the same length?

4. Is the red stick longer than the blue stick?

Stimulus Materials: See Figure 17 for stimuli.

Four questions comparable to questions 1 through 4 are asked of the weights of the same sticks.

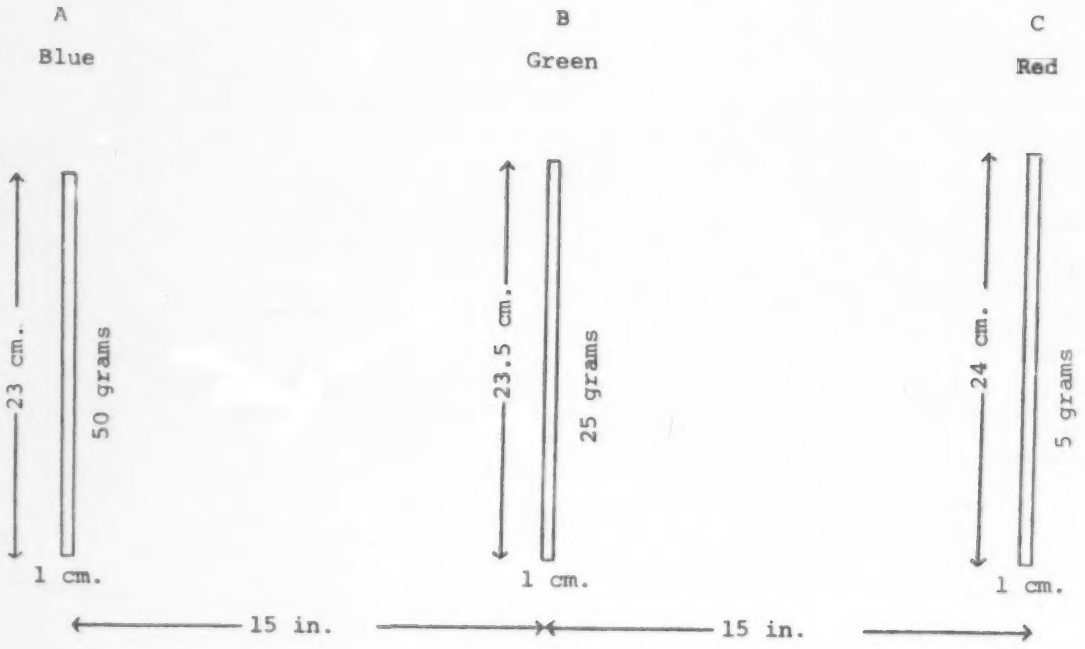


Figure 17. Drawing of stimuli for *Groupement* V.

(Preliminary comparisons are made to establish that the blue stick is shorter than the green stick by moving them together and that the green stick is shorter than the red stick by then moving them together. However, the blue and the red sticks are not directly compared in order to prevent that their comparison be made on a purely perceptual basis.)

Groupement VI: Addition of Symmetrical Relations

Operations: A. Composition (addition) of equivalence relations

$(A \leftrightarrow B) + (B \leftrightarrow C) = (A \leftrightarrow C)$

Questions: 1. Are the blue and red sticks the same length?

2. Is the blue stick shorter than the red stick?

B. Reciprocity of equivalence relations $[(A \leftrightarrow B) + (B \leftrightarrow C) = (A \leftrightarrow C)] + [(C \leftrightarrow B) + (B \leftrightarrow A) = (C \leftrightarrow A)] = (A \leftrightarrow A)$

Questions: 3. Are the red and blue sticks the same length?

4. Is the red stick longer than the blue stick?

Stimulus Materials: See Figure 18 for stimuli.

Four questions comparable to questions 1 through 4 are asked of the weights of the same sticks.

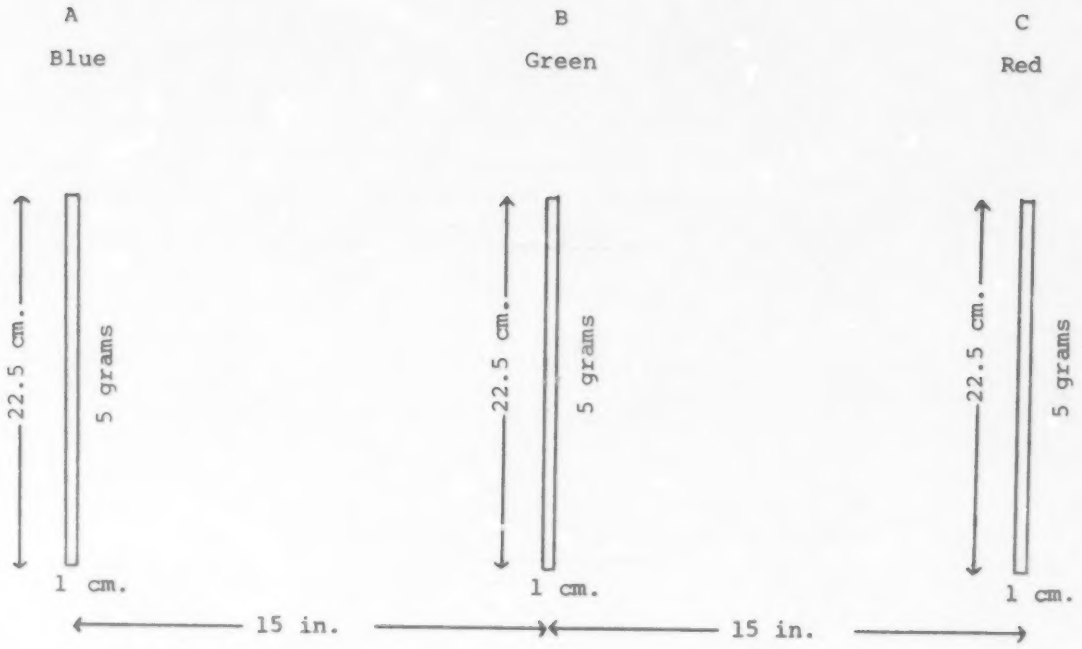


Figure 18. Drawing of stimuli for *Groupement* VI.

(Preliminary comparisons are made to establish that the blue and the green sticks are the same length by moving them together and that the green and the red sticks are the same length by then moving them together. However, the blue and the red sticks are not directly compared in order to prevent that their comparison be made on a purely perceptual basis.)

Groupement VII: Bi-univocal Multiplication of Relations

Operations: A. Composition (multiplication) of difference relations $(A \leftrightarrow B) \times (B \leftrightarrow C) = (A \leftrightarrow C)$

Questions: 1. Is the red stick shorter than the green stick?

2. Is the red stick lighter than the green stick?

B. Reciprocity of difference relations $[(C \rightarrow B) \times (B \rightarrow A)] \div (C \rightarrow A) = A \overset{\circ}{\rightarrow}_{\circ} A$

Questions: 3. Is the green stick longer than the red stick?

4. Is the green stick heavier than the red stick?

Stimulus Materials: See Figure 19 for stimuli.

Four supplementary questions are also included.

Figure 19. Drawing of stimuli for *Groupement* VII.

(Preliminary comparisons are made to establish that the red stick is both shorter and lighter than the blue stick by moving them together and placing them in the S's hands and that the blue stick is both shorter and lighter than the green stick by then moving them together and placing them in the S's hands. However, the red and the green sticks are not moved together nor placed in the S's hands simultaneously in order to prevent that their comparison be made on a purely perceptual basis.)

Groupement VIII: Co-univocal Multiplication of Relations

Operations: A. Composition (multiplication) of difference relations by equivalence relations $(A \leftrightarrow\!\!\!\!\downarrow\ B) \times (B \leftrightarrow\!\!\!\!\downarrow\ C) = (A \leftrightarrow\!\!\!\!\downarrow\ C)$

Questions: 1. Do the green and blue sticks weigh the same?

2. Is the green stick shorter than the blue stick?

B. Reciprocity of difference relations by equivalence relations $[(C \leftrightarrow\!\!\!\!\uparrow\ B) \times (B \leftrightarrow\!\!\!\!\uparrow\ A)] \div (C \leftrightarrow\!\!\!\!\uparrow\ A) = (A \overset{\circ}{\leftrightarrow\!\!\!\!\uparrow}_{\circ}\ A)$

Questions: 3. Do the blue and green sticks weigh the same?

4. Is the blue stick longer than the green stick?

Stimulus Materials: See Figure 20 for stimuli.

Four supplementary questions are also included.

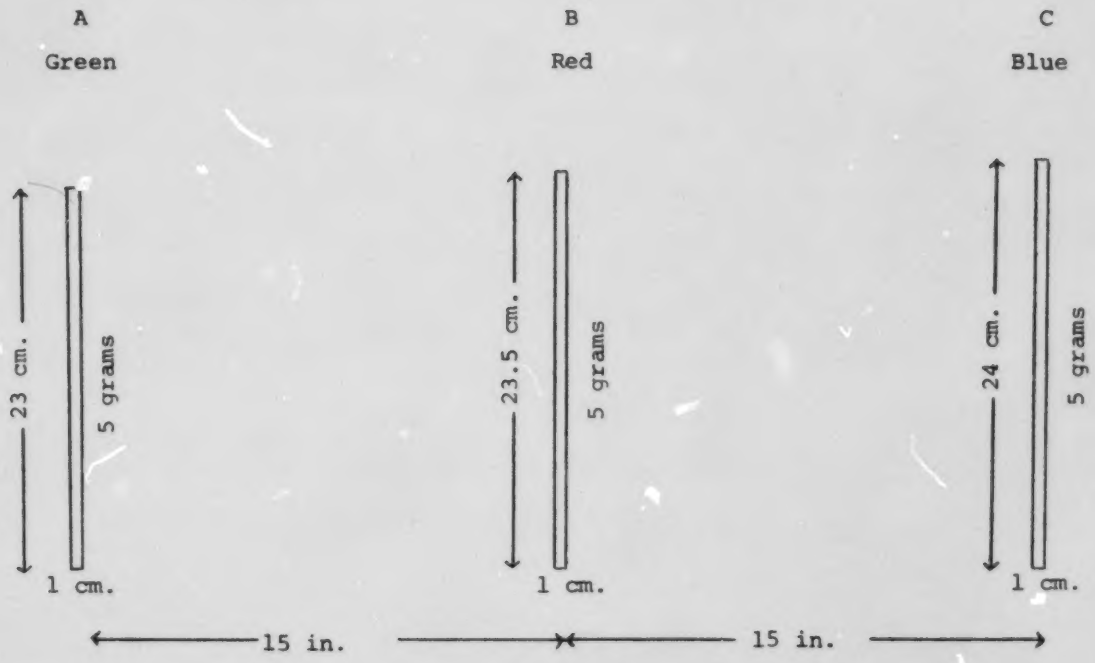


Figure 20. Drawing of stimuli for *Groupement* VIII.

(Preliminary comparisons are made to establish that the green stick is shorter than and the same weight as the red stick by moving them together and placing in the S's hands and that the red stick is shorter than and the same weight as the blue stick by then moving them together and placing them in the S's hands. However, the green and the blue sticks are not moved together nor placed in the S's hand simultaneously in order to prevent that their comparison be made on a purely perceptual basis.)

Traditional Piagetian classification tasks.

1. Dichotomies (Score Range = 0-3)

S is asked to sort, according to one of the three dimensions, 22 pictorial stimuli varying on the dimensions of color (red or blue), shape (square or circle), and number (one or two objects per stimulus), regroup the same stimuli on another of the dimensions, and finally regroup the same stimuli on the third dimension. 3 items. Adapted from Kamii and Peper (1969).

2. Some-all (Score Range = 0-4)

In reference to five triangles--three red and two blue--and four blue circles, the S is asked questions representing each of the following two relationships: (1) All members of a subclass are members of a higher class. 2 items. (2) Some but not all members of a higher class are members of a given subclass. 2 items. Adapted from Kofsky (1966).

3. Class Inclusion (Score Range = 0-5)

a. In reference to triangles, three red and two blue, the S is asked whether there are more members of the superordinate class (triangles) than members of the nested subclass (red figures). 1 trial. (The procedure is repeated using circles in another trial.)

b. In reference to triangles--three red and two blue--and four blue circles, the S is asked whether there are more members of the superordinate class (triangles) than members of the nested subclass (red figures). 1 trial. (The procedure is repeated

in another trial with the same stimuli using blue figures as the superordinate class and circles as the nested subclass.)

c. In reference to the same stimuli used in (b), the S is asked which of the intersecting classes (blue figures or triangles) is larger. 1 trial. 5 total Class Inclusion items. Adapted from Kofsky (1966).

4. Combinatorial Reasoning (Score Range = 0-28)

The S is asked to form all possible (28) pairs of eight differently colored chips without repeating pairs. Adapted from Goodnow (1962).

5. Cardinality Task Series (Score Range = 0-5)

The S is asked to judge (a) the non-equivalence of number of two parallel rows of dots of unequal number dispersed over equal lengths, (b) the non-equivalence of number of two parallel rows of dots of unequal number dispersed over unequal lengths, (c) the equivalence of number of two parallel rows of dots of equal number dispersed over unequal lengths, (d) the equivalence or non-equivalence of number of two pairs of single digit numbers presented verbally, and (e) the equivalence or non-equivalence of number of two parallel rows of dots of equal number dispersed over equal lengths. 5 judgments. Adapted from Brainerd (1973a) and Gonchar (1975).

Traditional Piagetian relations tasks.

1. Seriation Task Series (Score Range = 0-5)

a. Serial Construction

The S is asked to order (1) an array of seven sticks that differ in length (by one centimeter increments), and (2) an array of 10 circles that differ in diameter (by three centimeter increments). Adapted from Elkind (1964).

b. Additive Seriation

The S is asked to insert three additional sticks into their proper place in an existing ordered array of seven sticks. Adapted from Elkind (1964).

c. Serial Correspondence: Matching Case

Given a seriated array of sticks and a seriated array of circles, the S is asked to match each member of one seriated array with the corresponding member of the other seriated array. Adapted from Coxford (1964).

d. Serial Correspondence: Extension and Compression Cases

The members of one seriated array are first extended, then compressed, and under each condition the S is asked to match three members of the deformed array to the corresponding members of a second, unmanipulated, seriated array. Adapted from Coxford (1964).

e. Serial Correspondence: Scrambled Case

The members of one seriated array are reoriented in a scrambled fashion, and the S is asked to match three members of the deformed array to the corresponding members of a second, unmanipulated, seriated array. Adapted from Coxford (1964).

2. Transitivity of Length (Score Range = 0-5)

The S compares (1) one stick A to another stick B in terms of their equal lengths, (2) stick A to a third stick C in terms of their unequal lengths, and is asked to judge the inequality of length of sticks B and C. 5 judgments. Adapted from Brainerd (1973b).

3. Transitivity of Weight (Score Range = 0-5)

The S compares (1) one clay ball A to another clay ball B in terms of their equal weights, (2) clay ball A to a third clay ball C in terms of their unequal weights, and is asked to judge the inequality of weight of clay balls B and C. 5 judgments. Adapted from Brainerd (1973b).

Conservation tasks.

1. Identity Conservation of Length (Score Range = 0-6)

The S is asked to (1) predict the length of a single string to be the same if perceptually altered (3 judgments, one followed by an explanation inquiry), and (2) judge the length of the string to be the same after being perceptually altered (3 judgments, one followed by an explanation inquiry). 6 judgments. Adapted from Hooper (1969) and Brainerd (1973b).

2. Equivalence Conservation of Length (Score Range = 0-6)

The S is asked to (1) predict the length of two perceptually equivalent strings to be equal if one were perceptually altered (3 judgments, one followed by an explanation inquiry), and

(2) judge the length of the strings to be equal after one has been perceptually altered (3 judgments, one followed by an explanation inquiry). 6 judgments. Adapted from Brainerd (1973b).

3. Identity Conservation of Weight (Score Range = 0-6)

The S is asked to (1) predict the weight of a piece of clay to be the same if perceptually altered (3 judgments, one followed by an explanation inquiry), and (2) judge the weight of the clay ball to be the same after being perceptually altered (3 judgments, one followed by an explanation inquiry). 6 judgments. Adapted from Hooper (1969) and Brainerd (1973b).

4. Equivalence Conservation of Weight (Score Range = 0-6)

The S is asked to (1) predict the weight of two perceptually equivalent clay balls to be equal if one were perceptually altered (3 judgments, one followed by an explanation inquiry), and (2) judge the weight of the clay balls to be equal after one has been perceptually altered (3 judgments, one followed by an explanation inquiry). 6 judgments. Adapted from Brainerd (1973b)

5. Conservation of Number (Score Range = 0-7)

The S is asked to (1) predict the number of two sets of chips to be equal if one of the sets were perceptually altered (3 judgments, one followed by an explanation inquiry), (2) judge the number of each of the sets to be equal after one has been perceptually altered (3 judgments, one followed by an explanation inquiry), and (3) judge the number of the sets to be unequal after one chip has been removed from one of the sets. 7 judgments. Adapted from Brainerd and Brainerd (1972) and Rothenberg (1969).

Arithmetic and memory tasks. The arithmetic operations task (Brainerd, 1973a) consisted of 16 incomplete addition equations, e.g., "How many apples is four apples plus three apples?". The items were presented in written form and read aloud to the child. The subject was permitted one and one-half minutes to complete the set of 16 items.

The visual orientation memory test (Swinton, 1973) assessed the child's ability to recognize and identify (following a 5-second study interval) a two dimensional geometric figure (line drawing) from a pictorial array of the same figure in varying spatial orientations. There were four possible rotation or reflection choices for each of 20 items. The auditory memory span test (Wepman & Morency, 1973a) consisted of a forward word series with three trials of differing word sets at each level from two to six words (score range = 0-60). The auditory sequential memory test (Wepman & Morency, 1973b) consisted of a forward digit series (two to eight digits) with two sets of differing numbers at each level (score range = 0-70).[2]

Technical Characteristics of the Tasks

Certain preliminary analyses were conducted on the initial year's cross-sectional data. No significant order of presentation effects were found. As anticipated, factorial analyses of variance indicated

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[2] Information regarding these copyrighted memory task materials may be obtained from Language Research Associates, Inc., 175 E. Delaware Place, Chicago, Illinois 60611.

significant grade level effects for each *groupement* task, the class inclusion and combinatorial reasoning tasks, and each of the three memory measures. Sex differences were significant for only one of the measures, class inclusion, where female performances were found to be superior to those of their male counterparts at all three grade levels. There were no significant grade level x sex interactions. Grade level main effects were also significant for the remainder of the tasks except for the length transitivity case. While sex main effects were notably absent for all of these tasks, a significant grade level x sex interaction value resulted from a case of kindergarten female superiority and third grade male superiority for the equivalence length conservation task. Thus, children's performances on the present tasks appear to be significantly related to chronological age and generally free of notable sex biases.

Hoyt reliability coefficients, formally analogous to coefficient alpha, and associated standard errors of measurement are reported in Tables 14 through 18 (conventional reliability indices were not seen as appropriate for the dichotomies and combinatorial reasoning tasks).[3] Despite serious reservations about the appropirateness of applying conventional psychometric analyses to Piagetian concept task settings (cf. Carver, 1974), the following information may be used for general comparison purposes to more traditional ability measures. As Table 14 indicates, the Hoyt reliability values for the various *groupement*

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[3] These analyses were computed using the LERTAP test analysis program, Version 2, 1974, Madison Academic Computing Center, University of Wisconsin, Madison, Wisconsin.

TABLE 14

HOYT RELIABILITIES FOR VARIOUS *GROUPEMENT* SUBSCALES
COMBINING KINDERGARTEN, THIRD, AND SIXTH GRADES (N = 180)
(INITIAL ASSESSMENT YEAR'S RESULTS)

Subscale	Hoyt	Standard Error of Measurement
All (64) *Groupement* Items	.88	3.01
All (32) Class *Groupement* (I-IV) Items	.85	2.21
All (32) Relational *Groupement* (V-VIII) Items	.84	1.90
All (32) Composition *Groupement* Items	.81	2.32
All (32) Inversion/Reciprocity *Groupement* Items	.84	1.81
All (16) Class Composition *Groupement* Items	.85	1.61
All (16) Class Inversion *Groupement* Items	.78	1.29
All (16) Relational Composition *Groupement* Items	.71	1.44
All (16) Relational Reciprocity *Groupement* Items	.75	1.18
All (8) *Groupement* I Items	.52	.91
All (8) *Groupement* II Items	.67	.92
All (8) *Groupement* III Items	.69	1.13
All (8) *Groupement* IV Items	.76	1.03
All (8) *Groupement* V Items	.67	.81
All (8) *Groupement* VI Items	.78	.62
All (8) *Groupement* VII Items	.75	.93
All (8) *Groupement* VIII Items	.65	.99

Source: Hooper, Brainerd, & Sipple, 1975.

TABLE 15

HOYT RELIABILITIES FOR VARIOUS CONSERVATION SUBSCALES
COMBINING KINDERGARTEN AND THIRD GRADE (N = 120)
(INITIAL ASSESSMENT YEAR'S RESULTS)

Subscale	Hoyt	Standard Error of Measurement
All (7) Conservation of Number Items	.87	.72
All (24) Conservation of Length and Weight Items (Supporting Explanation Required)	.95	1.75
All (24) Conservation of Length and Weight Items (Supporting Explanation Not Required)	.94	1.72
All (12) Conservation of Length Items (Supporting Explanation Required)	.94	1.06
All (12) Conservation of Length Items (Supporting Explanation Not Required)	.94	1.03
All (12) Conservation of Weight Items (Supporting Explanation Required)	.93	1.13
All (12) Conservation of Weight Items (Supporting Explanation Not Required)	.93	1.09
All (12) Identity Conservation Items (Supporting Explanation Required)	.87	1.24
All (12) Identity Conservation Items (Supporting Explanation Not Required)	.85	1.17
All (12) Equivalence Conservation Items (Supporting Explanation Required)	.93	1.12
All (12) Equivalence Conservation Items (Supporting Explanation Not Required)	.93	1.14
All (12) Conservation Prediction Items (Supporting Explanation Required)	.88	1.26
All (12) Conservation Prediction Items (Supporting Explanation Not Required)	.87	1.23
All (12) Conservation Judgment Items (Supporting Explanation Required)	.91	1.17
All (12) Conservation Judgment Items (Supporting Explanation Not Required)	.91	1.15

Source: Hooper, Brainerd, & Sipple, 1975.

TABLE 16

HOYT RELIABILITIES FOR THE SERIATION, TRANSITIVITY OF LENGTH, AND TRANSITIVITY OF WEIGHT SUBSCALES COMBINING KINDERGARTEN AND THIRD GRADE (N = 120) (INITIAL ASSESSMENT YEAR'S RESULTS)

Subscale	Hoyt	Standard Error of Measurement
All (5) Seriation Items	.63	.71
All (5) Transitivity of Length Items	.94	.39
All (5) Transitivity of Weight Items	.91	.33
All (10) Transitivity of Length and Weight Items Combined	.87	.81

Source: Hooper, Brainerd, & Sipple, 1975.

TABLE 17

HOYT RELIABILITIES FOR THE SOME-ALL AND CARDINALITY TASKS COMBINING KINDERGARTEN AND THIRD GRADE (N = 120) (INITIAL ASSESSMENT YEAR'S RESULTS)

Subscale	Hoyt	Standard Error of Measurement
All (4) Some-All Items	.37	.45
All (5) Cardinality Items	.72	.72

Source: Hooper, Brainerd, & Sipple, 1975.

TABLE 18

HOYT RELIABILITIES FOR SUBSCALES OF THE CLASS INCLUSION TASK COMBINING KINDERGARTEN, THIRD, AND SIXTH GRADES (INITIAL ASSESSMENT YEAR'S RESULTS)

Subscale	Hoyt	Standard Error of Measurement
Class Inclusion Items 1 through 4	.63	.63
All (5) Class Inclusion Items	.67	.75

Source: Hooper, Brainerd, & Sipple, 1975.

comparisons ranged from .62 to .88. For all comparisons which involved 16 or more items, the respective Hoyt values exceeded .70.

Table 15 presents the reliability values for the various conservation task items. Values ranged from .85 to .95. The average Hoyt value for the conservation tasks was .91, indicating an obviously acceptable level of reliability. Table 16 presents counterpart values for the additional relational concept tasks. Due to the different logical structure of class inclusion items one through four (i.e., nested subclasses) as opposed to item five (i.e., intersecting subclasses), two subscales for computing reliability coefficients were employed (see Table 18). It may be concluded that with the exception of the Some-All task, the present reliability values indicate a generally satisfactory level of internal consistency for the Piagetian task series.

Administration of the Tasks

The present task array was designed to ensure a certain minimal degree of inter-subject and inter-task standardization while maintaining essential comparability with the earlier Piagetian concrete operations concept assessment research. In contrast to the CLD assessment procedures, all measures were individually administered and an attempt was made to retain the desirable flexibility features of the *méthode clinique*. Thus, following the establishment of essential rapport with the subject, the task settings were administered in a relaxed, game-like

atmosphere intended to be nonanxiety producing. No explicit corrective reinforcement was introduced except in the initial warm-up sessions. Questions were restated if the child's responses were ambiguous or if an obvious misunderstanding of the criterial question was evident. The tasks were presented in three separate sessions[4] as follows:

Session One: (A) Seriation task series, (B) Conservation of number, (C) Arithmetic addition, (D) Cardinality, and (E) Dichotomous sorting.[5]

Session Two: (A) Memory tasks (visual orientation memory, auditory memory span [word series], and auditory sequential memory [digital span]), (B) *Groupement* tasks, (C) Combinatorial reasoning, and (D) "Some-all" relationships.

Session Three: (A) Conservation and Transitivity tasks series,[6] and (B) Class inclusion task.

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[4]Note that only a partial task array, e.g., memory tasks, *groupement* tasks, combinatorial reasoning, and class inclusion, was administered to the sixth grade and subsequent older subjects in a single session.

[5]The various tasks in the initial session were presented in one of the following four orders of presentation: E, D, A, B, C; A, C, D, B, E; E, B, D, C, A; C, B, A, D, E.

[6]The conservation and transitivity measures consisted of: conservation of length (identity and equivalence task formats), conservation of weight (identity and equivalence task formats), transitivity of length, and transitivity of weight. Following a "warm-up" exercise to ensure an understanding of the criterial reference terms, the identity, equivalence, and transitivity tasks were presented in one of six counter-balanced orders of presentation. The length cases always preceded the weight cases.

Treatment of Piagetian Task Data

Children's performances on each of 24 of the selected tasks based on Piagetian theory were scored as either passing or failing; that is, results were treated as dichotomous data. The criteria for passing the tasks are presented in Table 19.

For the purposes of the correlational and factor analyses, it was decided to include each of 25 tasks[7] based on Piagetian theory, the three memory tests, and the arithmetic addition task. Therefore, the data from each of 29 measures were treated as interval data.

[7] The five seriation subtasks included in the pass/fail results were combined in the correlational and factor analyses to form a single measure of seriation ability. The five-item cardinality task was also used for these latter analyses only.

TABLE 19

NUMBER OF ITEMS AND CRITERIA DEFINING PASSING THE TASKS BASED ON PIAGETIAN THEORY

Task	Number of Items	Criteria for Passing
Groupement I:		
Primary Addition of Classes	4 composition and 4 inversion	3 composition and 3 inversion
Groupement II:		
Secondary Addition of Classes	"	"
Groupement III:		
Bi-univocal Multiplication of Classes	"	"
Groupement IV:		
Co-univocal Multiplication of Classes	"	"
Groupement V:		
Addition of Asymmetrical Relations	4 composition and 4 reciprocity	4 composition and 4 reciprocity
Groupement VI:		
Addition of Symmetrical Relations	"	"
Groupement VII:		
Bi-univocal Multiplication of Relations	"	"
Groupement VIII:		
Co-univocal Multiplication of Relations	"	"
Class Inclusion	5	5
Combinatorial Reasoning	28 pairs	28 pairs
Seriation Construction	2	2
Seriation Addition	1	1
Seriation Matching	1	1
Seriation Extension and Compression	2	2
Seriation Scrambled Case	1	1
Transitivity of Length	5	5
Transitivity of Weight	5	5
Some-All	4	4
Dichotomies	3	3
Conservation of Number	7	7
Identity Conservation of Length	6	6
Equivalence Conservation of Length	6	6
Identity Conservation of Weight	6	6
Equivalence Conservation of Weight	6	6

V

RESULTS FROM FIRST YEAR DATA COLLECTION

In the spring of 1973, the first time of data collection for this longitudinal study, all of the subtests of the CLD assessment battery dealing with equilateral triangle were administered to students in the kindergarten, third, and sixth grades. Ten tasks based upon Piagetian theory were administered to these same students, including eight *groupement* tasks and two traditional tasks: Class Inclusion and Combinatorial Reasoning. An additional fourteen traditional Piagetian tasks were administered only to the kindergarten and third grade children. Also, three memory tests were administered to the kindergarten, third, and sixth grade groups and a test of arithmetic addition to the kindergarten and third grade children. The students on whom data were collected in the first year but who were not available for data collection in the second year were dropped from the study so that the results of the second year data collection could be related more directly to the results of the first year data collection.

The results of the data collection are reported first in terms of the percent of students who passed a certain level of the CLD battery as their highest level and who also passed one or more of the Piagetian tasks administered to them. Then correlational matrices are presented and the results of factor analysis. In the next chapter, results are given at the

end of the second year for not only equilateral triangle but also two other concepts, noun and tree.

PERCENTAGE OF STUDENTS IN COMBINED KINDERGARTEN, THIRD, AND SIXTH GRADES WHO PASSED EACH CLD LEVEL OF EQUILATERAL TRIANGLE AND WHO ALSO PASSED EACH OF TEN PIAGETIAN TASKS

Table 20 shows the number of students who attained the concept equilateral triangle at a certain level as their highest attainment and who also passed each of the ten Piagetian tasks administered to all the students enrolled in kindergarten, third, and sixth grades. Fifteen of 156 students did not follow the invariant sequence predicted by the CLD theory. Individuals in this group always passed a higher level, e.g., classificatory, while failing a lower level, e.g., identity, and are therefore not included.

In Table 20 it is seen that three students passed no CLD level and six passed the concrete level. These numbers are regarded as too small to draw any conclusions; however, the data are presented so that all the students who followed the predicted patterns of attainment are included. Thirty-five students passed the identity level as their highest, 68 passed the classificatory level as their highest, and 29 passed the formal level as their highest attainment. The trend with respect to these highest levels of attainment and passing the various Piagetian tasks is very clear in relation to the four points selected for relating passage of the Piagetian tasks according to each of the four levels of the CLD task: less than 26 percent, from 26 percent through 50 percent, 51 percent through 75 percent, and 76 percent and above passing the respective Piagetian tasks. One way to summarize the tabular data is to consider the Piagetian tasks

TABLE 20

PERCENTAGE OF STUDENTS IN COMBINED KINDERGARTEN, THIRD, AND SIXTH GRADES WHO PASSED EACH OF TEN TASKS BASED ON PIAGETIAN THEORY ACCORDING TO HIGHEST LEVEL OF ATTAINMENT OF THE CONCEPT EQUILATERAL TRIANGLE

CLD level	Percentage Ranges Passing Piagetian Task	CLD Task Equilateral Triangle
None		n = 3
	0%-25%	Sec Add of Class (0%) Bi-univ Mult of Class (0%) Class Incl (0%) Comb Reas (0%)
	26%-50%	Co-univ Mult of Class (33%) Bi-univ Mult of Rel (33%) Co-univ Mult of Rel (33%)
	51%-75%	Prim Add of Class (67%) Add of Asym Rel (67%) Add of Sym Rel (67%)
	76%-100%	
Concrete		n = 6
	0%-25%	Prim Add of Class (0%) Bi-univ Mult of Class (0%) Co-univ Mult of Class (0%) Class Incl (0%) Comb Reas (0%) Sec Add of Class (17%) Add of Asym Rel (17%)
	26%-50%	Co-univ Mult of Rel (50%)
	51%-75%	Add of Sym Rel (67%) Bi-univ Mult of Rel (67%)
	76%-100%	
Identity		n = 35
	0%-25%	Comb Reas (0%) Prim Add of Class (9%) Sec Add of Class (9%) Bi-univ Mult of Class (11%) Co-univ Mult of Class (14%) Class Incl (14%)

TABLE 20, continued.

CLD level	Percentage Ranges Passing Piagetian Task	CLD Task Equilateral Triangle
	26%-50%	Co-univ Mult of Rel (31%)
	51%-75%	Bi-univ Mult of Rel (60%) Add of Asym Rel (71%)
	76%-100%	Add of Sym Rel (76%)
Classificatory		n = 68
	0%-25%	Bi-univ Mult of Class (12%) Comb Reas (12%) Prim Add of Class (15%) Sec Add of Class (22%)
	26%-50%	Co-univ Mult of Class (34%) Class Incl (41%)
	51%-75%	Bi-univ Mult of Rel (60%) Co-univ Mult of Rel (65%) Add of Asym Rel (72%)
	76%-100%	Add of Sym Rel (88%)
Formal		n = 29
	0%-25%	
	26%-50%	Bi-univ Mult of Class (45%) Comb Reas (48%)
	51%-75%	Prim Add of Class (52%) Sec Add of Class (55%) Class Incl (66%)
	76%-100%	Co-univ Mult of Class (76%) Add of Asym Rel (83%) Bi-univ Mult of Rel (86%) Co-univ Mult of Rel (86%) Add of Sym Rel (100%)

passed by 51 percent or more of the students who attained each CLD level as their highest. The majority of students who mastered the identity level as their highest also passed Addition of Symmetric Relations (76 percent), Addition of Asymmetric Relations (71 percent), and Bi-univocal Multiplication of Relations (60 percent); less than 50 percent of the students who mastered the identity level also mastered the other Piagetian tasks and 0 percent mastered Combinatorial Reasoning. The majority of students who mastered the classificatory level as their highest also mastered four Piagetian tasks: Addition of Symmetric Relations (88 percent), Addition of Asymmetric Relations (72 percent), Co-univocal Multiplication of Relations (65 percent), and Bi-univocal Multiplication of Relations (60 percent). The majority of all students (N = 29) who passed the formal level also passed all four of the Piagetian relations *groupement* tasks, three of the four Piagetian class *groupement* tasks, and Class Inclusion. Less than half passed Combinatorial Reasoning (48 percent) and Bi-univocal Multiplication of Classes (45 percent). Finally, one result is apparent from visual inspection of the tabular data, namely, a higher percentage of the students who master each successively higher CLD level also master the Piagetian tasks.

PERCENTAGE OF STUDENTS IN COMBINED KINDERGARTEN, THIRD, AND SIXTH GRADES WHO PASSED THE CLD USES OF EQUILATERAL TRIANGLE AND WHO ALSO PASSED EACH OF TEN PIAGETIAN TASKS

The CLD model predicts that the higher the level of concept attained, relationships, in understanding principles, and in understanding problems. Certain of the Piagetian tasks are presumed also to be related to understanding taxonomic relationships, understanding principles, and solving

problems. The relationships between the various uses as measured by the CLD batteries and performances on the Piagetian tasks will be determined as more students pass the CLD uses tests in the two ensuing years.

Table 21 shows that only 6 of the 156 students passed the taxonomic relationships test, three passed the principle test, while none passed the problem solving test. The numbers are regarded as too small to draw any conclusions particularly since the numbers of students passing the various uses tests will be greater in later years of the study.

PERCENTAGE OF STUDENTS IN COMBINED KINDERGARTEN AND THIRD GRADES WHO PASSED EACH CLD LEVEL OF EQUILATERAL TRIANGLE AND WHO ALSO PASSED EACH OF 14 PIAGETIAN TASKS

Fourteen of the Piagetian tasks were not administered to the sixth grade students in the first year of the study on the assumption that they were too easy and that all the sixth graders would therefore pass the tasks. (This assumption proved to be partially incorrect; and all the tests will be administered to children who become sixth graders in the final year of the study.) In this section, the comparisons between students passing various levels of the CLD battery and the 14 Piagetian tasks administered to only the kindergarten and third grade children are presented. Table 22 gives these results. As in the prior section, the number of students is given according to five categories of the CLD battery. The numbers for passing no level and the concrete level are too small to arrive at any reliable conclusions; however, the trends shown by the 33 students passing the identity level as their highest, 39 passing the classificatory level as their highest, and the 7 passing formal as their highest level merit consideration.

TABLE 21

PERCENTAGE OF STUDENTS IN COMBINED KINDERGARTEN, THIRD, AND SIXTH GRADES WHO PASSED EACH CLD USE OF EQUILATERAL TRIANGLE AND WHO ALSO PASSED EACH OF TEN TASKS BASED ON PIAGETIAN THEORY

CLD level	Percentage Ranges Passing Piagetian Task	CLD Task Equilateral Triangle
Taxonomic Relationships		n = 6
	0%-25%	Prim Add of Class (17%) Sec Add of Class (17%) Bi-univ Mult of Class (17%) Comb Reas (17%)
	26%-50%	Class Incl (50%)
	51%-75%	Add of Asym Rel (67%)
	76%-100%	Co-univ Mult of Class (83%) Bi-univ Mult of Rel (83%) Co-univ Mult of Rel (83%) Add of Sym Rel (100%)
Principle		n = 3
	0%-25%	
	26%-50%	
	51%-75%	Prim Add of Class (67%) Bi-univ Mult of Class (67%) Co-univ Mult of Class (67%) Class Incl (67%) Comb Reas (67%)
	76%-100%	Sec Add of Class (100%) Add of Asym Rel (100%) Add of Sym Rel (100%) Bi-univ Mult of Rel (100%) Co-univ Mult of Rel (100%)
Problem Solving		n = 0

TABLE 22

PERCENTAGE OF STUDENTS IN COMBINED KINDERGARTEN AND THIRD GRADE WHO PASSED EACH OF 14 PIAGETIAN TASKS ACCORDING TO HIGHEST LEVEL OF ATTAINMENT OF THE CONCEPT EQUILATERAL TRIANGLE

CLD level	Percentage Ranges Passing Piagetian Task	CLD Task Equilateral Triangle
None		n = 3
	0%-25%	Ser Const (0%) Ser Ext-Comp (0%) Ser Scr (0%) Dich (0%) Cons of No. (0%) Id Cons of Lgth (0%) Eq Cons of Lgth (0%) Id Cons of Wgt (0%) Eq Cons of Wgt (0%)
	26%-50%	Ser Add (33%)
	51%-75%	Trans of Lgth (67%) Trans of Wgt (67%) Some-all (67%)
	76%-100%	Ser Match (100%)
Concrete		n = 6
	0%-25%	Ser Scr (0%) Dich (0%) Id Cons of Lgth (0%) Eq Cons of Lgth (0%) Id Cons of Wgt (0%) Eq Cons of Wgt (0%) Ser Ext-Comp (17%)
	26%-50%	Ser Const (33%) Cons of No. (33%) Ser Add (50%) Ser Match (50%)
	51%-75%	Trans of Lgth (67%) Trans of Wgt (67%) Some-all (67%)
	76%-100%	

TABLE 22, continued.

CLD level	Percentage Ranges Passing Piagetian Task	CLD Task Equilateral Triangle
Identity		n = 33
	0%-25%	Ser Scr (12%) Dich (12%) Ser Ext-Comp (15%)
	26%-50%	Eq Cons of Wgt (27%) Id Cons of Lgth (36%) Eq Cons of Lgth (39%) Id Cons of Wgt (39%)
	51%-75%	Cons of No. (55%) Ser Const (61%) Trans of Lgth (67%)
	76%-100%	Some-all (76%) Trans of Wgt (82%) Ser Match (88%) Ser Add (91%)
Classificatory		n = 39
	0%-25%	Dich (21%) Ser Scr (23%)
	26%-50%	Ser Ext-Comp (41%)
	51%-75%	Eq Cons of Wgt (59%) Eq Cons of Lgth (67%) Cons of No. (72%) Id Cons of Lgth (72%) Id Cons of Wgt (72%)
	76%-100%	Ser Const (82%) Some-all (85%) Ser Add (87%) Trans of Lgth (87%) Ser Match (92%) Trans of Wgt (95%)

TABLE 22, continued.

CLD level	Percentage Ranges Passing Piagetian Task	CLD Task Equilateral Triangle
Formal		n = 7
	0%-25%	
	26%-50%	
	51%-75%	Ser Scr (57%) Ser Ext-Comp (71%) Trans of Lgth (71%) Dich (71%) Id Cons of Lgth (71%)
	76%-100%	Eq Cons of Lgth (86%) Id Cons of Wgt (86%) Eq Cons of Wgt (86%) Ser Const (100%) Ser Add (100%) Ser Match (100%) Trans of Wgt (100%) Some-all (100%) Cons of No. (100%)

Fifty-one percent or more of the 33 students who passed the identity level of equilateral triangle as their highest level also passed the following Piagetian tasks: Seriation Addition (91 percent), Seriation Matching (88 percent), Transitivity of Weight (82 percent), Some-All (76 percent), Transitivity of Length (67 percent), Seriation Construction (61 percent), Conservation of Number (55 percent). Fifty-one percent or more of the students who passed the classificatory level as their highest performance also mastered the two transitivity measures, three of five seriation measures, some-all relations, and the five conservation tests including number, the two cases of length, and the two cases of weight. The three Piagetian tasks passed by less than 51 percent of the children passing the classificatory level as their highest were Seriation Extension and Compression, Seriation Scrambled Case, and Dichotomies. Fifty-one percent or more of the students who passed the formal level as their highest passed all 14 Piagetian tests.

The trend for an increasingly higher percent of students to pass each Piagetian task at each of the successively higher levels of the CLD test is clear. There is only an occasional variation involving a very low percent.

CORRELATIONAL RESULTS FOR COMBINED KINDERGARTEN, THIRD, AND SIXTH GRADES INVOLVING LEVEL OF ATTAINMENT SCORE AND EACH OF THREE USES SCORES FOR EQUILATERAL TRIANGLE, TEN PIAGETIAN TASK SCORES, AND THREE MEMORY TEST SCORES

In the preceding sections of this chapter, the percent of students across combined grades who passed each level of the CLD task and who also passed various Piagetian tasks have been reported. In this section, we present information on the same combined groups.

Table 23 shows total number of items per test, the means, and standard deviations for the CLD tasks, the same information for tasks based on Piagetian theory, and for three memory tests for the same kindergarten, third-, and sixth-grade students as discussed earlier. In other reports the means and standard deviations for the separate grade groups are given and discussed (Hooper, Swinton, & Sipple, 1976; Klausmeier, Allen, Sipple, & White, 1975).

Table 24 is the correlation matrix for the combined kindergarten, third, and sixth grades. These correlations will not be discussed further in this chapter because in Chapter VI the correlations from data collected in the second year involving the same groups will be reported and also the results of a related exploratory factor analysis.

CORRELATIONAL RESULTS FOR COMBINED KINDERGARTEN AND THIRD GRADE INVOLVING LEVEL OF ATTAINMENT SCORE AND EACH OF THREE USES SCORES FOR EQUILATERAL TRIANGLE, TWENTY-ONE PIAGETIAN TASK SCORES, THREE MEMORY TEST SCORES, AND AN ARITHMETIC ADDITION SCORE

Table 25 gives the means and standard deviations of the combined kindergarten and third grade groups on twenty-nine tests. The same information for each separate grade group is presented and discussed in other reports.

Table 26 presents the correlation matrix involving the 29 test scores. In Chapter VI, the correlation matrices based on data gathered at the end of the second year are presented as are the results of an exploratory factor analysis.

TABLE 23

MEANS AND STANDARD DEVIATIONS ON LEVEL OF ATTAINMENT AND EACH OF THREE USES FOR EQUILATERAL TRIANGLE TASK, TEN TASKS BASED ON PIAGETIAN THEORY, AND THREE MEMORY TESTS FOR COMBINED KINDERGARTEN, THIRD, AND SIXTH GRADES (N = 156)

Task	Total Items	Mean	Standard Deviation
Total levels of Eq. Tri.	29	22.55	3.99
Sup-Sub for Eq. Tri.	8	2.31	2.01
Prin for Eq. Tri.	11	2.06	3.07
Prob Solv for Eq. Tri.	6	1.22	1.27
Prim Add of Class	8	5.04	1.58
Sec Add of Class	8	5.28	1.68
Bi-univ Mult of Class	8	3.76	2.22
Co-univ Mult of Class	8	5.04	2.30
Class Incl	5	3.56	1.44
Comb Reas	28	17.55	9.99
Add of Asym Rel	8	6.96	1.48
Add of Sym Rel	8	7.32	1.44
Bi-univ Mult of Rel	8	6.13	2.04
Co-univ Mult of Rel	8	6.15	1.76
Aud Seq Mem	70	29.40	12.50
Aud Mem Span	60	30.60	10.20
Visual Mem	20	13.44	4.43

TABLE 24

INTERCORRELATIONS AMONG 17 VARIABLES FOR THE COMBINED KINDERGARTEN, THIRD, AND SIXTH GRADES FOR THE YEAR ONE ASSESSMENTS

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 Total levels of Eq. Tri.	1.000																
2 Sup-Sub for Eq. Tri.	.655																
3 Prin for Eq. Tri.	.600	.456															
4 Prob Solv for Eq. Tri.	.615	.582	.564														
5 Prim Add of Class	.413	.243	.536	.348													
6 Sec Add of Class	.370	.220	.521	.364	.691												
7 Bi-univ Mult of Class	.250	.161	.336	.226	.333	.322											
8 Co-univ Mult of Class	.401	.394	.418	.372	.411	.386	.368										
9 Class Incl	.533	.400	.383	.404	.271	.223	.163	.396									
10 Comb Reas	.616	.546	.505	.495	.347	.297	.192	.445	.488								
11 Add of Asym Rel	.278	.222	.184	.250	.161	.033	.208	.301	.275	.213							
12 Add of Sym Rel	.346	.349	.166	.234	.119	.040	.095	.329	.341	.387	.265						
13 Bi-univ Mult of Rel	.271	.238	.253	.231	.201	.126	.034	.203	.236	.206	.308	.260					
14 Co-univ Mult of Rel	.452	.266	.364	.440	.304	.140	.265	.261	.382	.352	.348	.444	.447				
15 Aud Seq Mem	.491	.290	.401	.365	.297	.312	.140	.299	.259	.367	.193	.145	.178	.282			
16 Aud Mem Span	.457	.337	.370	.379	.232	.283	.202	.329	.315	.391	.167	.193	.151	.274	.721		
17 Visual Mem	.711	.580	.642	.593	.386	.355	.148	.394	.477	.675	.273	.321	.284	.418	.367	.375	1.000

TABLE 25

MEANS AND STANDARD DEVIATIONS ON LEVEL OF ATTAINMENT AND EACH OF THREE USES FOR EQUILATERAL TRIANGLE TASK, 21 TASKS BASED ON PIAGETIAN THEORY, THREE MEMORY TESTS, AND ARITHMETIC ADDITION TASK FOR COMBINED KINDERGARTEN AND THIRD GRADE (N = 102)

Task	Mean	Standard Deviation
Total levels of Eq. Tri.	20.84	3.67
Sup-Sub for Eq. Tri.	1.64	1.89
Prin for Eq. Tri.	0.00	0.00
Prob Solv for Eq. Tri.	0.71	1.05
Prim Add of Class	4.44	1.36
Sec Add of Class	4.69	1.49
Bi-univ Mult of Class	3.30	2.02
Co-univ Mult of Class	4.38	2.15
Class Incl	3.13	1.46
Comb Reas	13.93	9.62
Add of Asym Rel	6.75	1.49
Add of Sym Rel	7.16	1.56
Bi-univ Mult of Rel	5.76	2.24
Co-univ Mult of Rel	5.71	1.79
Aud Seq Mem	26.17	11.92
Aud Mem Span	27.94	9.34
Visual Mem	11.31	3.86
Dich	1.57	0.94
Some-all	3.74	0.54
Cardinal	2.88	1.48
Trans of Lgth	4.01	1.81
Trans of Wgt	4.63	1.06
Seriation	2.86	1.32
Cons of No.	5.46	2.15
Id Cons of Lgth	4.25	1.87
Eq Cons of Lgth	3.40	2.64
Id Cons of Wgt	4.27	1.94
Eq Cons of Wgt	3.42	2.67
Arith Add	10.93	6.22

TABLE 26

INTERCORRELATIONS AMONG 29 VARIABLES FOR THE COMBINED KINDERGARTEN AND THIRD GRADE FOR THE YEAR ONE ASSESSMENTS

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Total levels of Eq. Tri.	1.000													
2	Sup-Sub for Eq. Tri.	.613													
3	Prin for Eq. Tri.	.000	.000												
4	Prob Solv for Eq. Tri.	.505	.581	.000											
5	Prim Add of Class	.137	-.014	.000	.057										
6	Sec Add of Class	.107	.026	.000	.099	.523									
7	Bi-univ Mult of Class	.072	-.020	.000	-.055	.195	.209								
8	Co-univ Mult of Class	.179	.293	.000	.283	.205	.245	.225							
9	Class Incl	.430	.335	.000	.318	.064	.102	.006	.271						
10	Comb Reas	.507	.554	.000	.390	.084	.142	.037	.366	.390					
11	Add of Asym Rel	.294	.240	.000	.214	.044	-.044	.134	.293	.300	.128				
12	Add of Sym Rel	.319	.370	.000	.259	.070	-.004	-.075	.245	.261	.398	.252			
13	Bi-univ Mult of Rel	.147	.120	.000	.160	.125	-.008	-.130	.074	.141	.053	.277	.212		
14	Co-univ Mult of Rel	.373	.211	.000	.338	.147	-.016	.142	.111	.330	.178	.285	.484	.360	
15	Aud Seq Mem	.442	.257	.000	.244	.045	.037	-.004	.165	.140	.268	.193	.119	.133	.204
16	Aud Mem Span	.472	.399	.000	.326	.066	.034	.083	.254	.247	.350	.160	.230	.062	.203
17	Visual Mem	.563	.540	.000	.394	.054	.060	-.066	.228	.362	.583	.181	.314	.109	.242
18	Dich	.400	.352	.000	.423	.088	.037	.085	.352	.326	.440	.314	.358	.163	.377
19	Some-all	.272	.272	.000	.244	.119	.153	-.025	.045	.234	.313	.152	.049	.111	.072
20	Cardinal	.549	.525	.000	.423	.153	.064	.055	.364	.356	.668	.216	.534	.093	.448
21	Trans of Lgth	.151	.103	.000	.174	.042	.119	.029	.057	.082	.054	.170	.108	.247	.217
22	Trans of Wgt	.196	.046	.000	.176	-.008	-.006	.053	.093	.270	.068	.149	.179	-.004	.280
23	Seriation	.592	.604	.000	.514	.029	.038	.075	.245	.412	.535	.281	.501	.150	.463
24	Cons of No.	.508	.518	.000	.430	.045	-.019	-.030	.135	.319	.554	.247	.440	.171	.370
25	Id Cons of Lgth	.467	.378	.000	.297	.096	-.035	.076	-.025	.344	.349	.187	.470	.088	.339
26	Eq Cons of Lgth	.460	.426	.000	.311	.115	.027	.071	.081	.248	.358	.139	.395	.065	.259
27	Id Cons of Wgt	.400	.369	.000	.186	.021	.061	.021	.081	.261	.275	.172	.333	.042	.195
28	Eq Cons of Wgt	.422	.432	.000	.246	.145	.118	.035	.051	.179	.235	.194	.389	.207	.363
29	Arith Add	.589	.673	.000	.528	-.030	-.046	.009	.262	.481	.567	.214	.561	.093	.418

TABLE 26, continued.

Variables	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
15 Aud Seq Mem	1.000														
16 Aud Mem Span	.779														
17 Visual Mem	.277	.336													
18 Dich	.279	.302	.524												
19 Some-all	.124	.209	.262	.240											
20 Cardinal	.357	.474	.616	.603	.145										
21 Trans of Lgth	.055	.071	.017	.119	-.058	.137									
22 Trans of Wgt	.178	.168	.181	.135	-.018	.198	.141								
23 Seriation	.335	.423	.585	.591	.266	.719	.121	.345							
24 Cons of No.	.212	.295	.549	.601	.182	.747	.144	.111	.655						
25 Id Cons of Lgth	.169	.221	.381	.318	.145	.419	.052	.143	.457	.532					
26 Eq Cons of Lgth	.207	.236	.444	.338	.185	.426	.012	.117	.441	.499	.814				
27 Id Cons of Wgt	.140	.204	.337	.333	.173	.452	.078	.156	.464	.510	.452	.446			
28 Eq Cons of Wgt	.148	.188	.296	.322	.125	.440	.118	.105	.469	.412	.430	.463	.698		
29 Arith Add	.343	.447	.576	.568	.273	.704	.173	.248	.770	.652	.462	.511	.505	.469	1.000

VI

RESULTS FROM SECOND YEAR DATA COLLECTION

During the second year of the longitudinal study data were collected on the children enrolled in the first, fourth, seventh, and tenth grades who had participated in the first year data collection as kindergarten, third, sixth, and ninth grade children. The Piagetian tasks were administered only to children in the first, fourth, and seventh grades. The first and fourth grade children received the assessment batteries of the CLD series including equilateral triangle, noun, and tree and 24 Piagetian tasks, 3 memory tests, and an arithmetic addition test. The seventh grade children received the CLD batteries dealing with equilateral triangle, noun, and tree; however, they received only 10 Piagetian tasks and the 3 memory tests.

In this chapter, the results are presented for grades one and four combined and for grades one, four, and seven combined. The first set of results deal with comparisons based on pass/fail scores of the various CLD batteries and Piagetian tasks. The correlation matrices are presented based on interval scores. The results of factor analyses are presented last.

PERCENTAGE OF STUDENTS IN COMBINED FIRST, FOURTH, AND SEVENTH GRADES WHO PASSED EACH CLD LEVEL OF TREE, EQUILATERAL TRIANGLE AND NOUN AND WHO ALSO PASSED EACH OF TEN PIAGETIAN TASKS

In order to facilitate interpretation of the results, a decision was made to prepare a table showing the number of students who attained the various concepts at a certain level as their highest attainment and who also passed the various Piagetian tasks. The percentages passing the Piagetian tasks were grouped in the ranges of 0-25 percent, 26-50 percent, 51-75 percent, and 76-100 percent. In addition, it was decided to report the exact percentages passing the various Piagetian tasks. Table 27 presents these results. In the left column are given the various CLD levels that were passed as the highest by the children: none, concrete, identity, classificatory, formal. In the corresponding row are given the number of students who passed that particular level as their highest level for each concept, tree, equilateral triangle, and noun. In the next column is given the four ranges of percents of students who passed the Piagetian tasks.

The number of students passing no levels and the concrete level as their highest was so low that it was decided not to deal further with this category. While the numbers are relatively high for noun, 15 and 22, it is recognized that the words representing nouns as used in these subtests of the CLD battery represent things that are nouns. This is not true of the other concepts where pictorial representations of examples and nonexamples were used. Therefore, comparisons of the concrete level and the identity level of noun with the concrete and identity levels of tree and equilateral triangle should take this into account.

As shown in Table 27, the number of students passing the various levels of tree and equilateral triangle are much alike; however, not all of these students passing the levels are necessarily the same students. Passing the same levels of noun occurred much later than for either tree or equilateral triangle. The later passing of the higher levels of noun is related to the fact that the examples and nonexamples of nouns cannot be experienced directly through the senses as can those for tree and equilateral triangle. One way of highlighting the results is to identify the Piagetian tasks that 51 percent or more of the students at each of the CLD levels passed for each tree and equilateral triangle, then the same results will be given for noun.

Of the 31 students who passed the identity level of tree as their highest performance and of the 29 who similarly passed the identity level of equilateral triangle, 51 percent or more also mastered the same four Piagetian tasks: Bi-univocal Multiplication of Relations, Co-univocal Multiplication of Relations, Addition of Asymmetric Relations, and Addition of Symmetric Relations. Less than 51 percent mastered the other six Piagetian tasks.

Of the 86 students who passed the classificatory level of tree as their highest level and the 94 students who passed the classificatory level of equilateral triangle as their highest, 51 percent or more mastered the four relations tasks above; also exactly 51 percent of those who passed the classificatory level of tree also mastered Co-univocal Multiplication of Classes.

Thirty-four students passed the formal level of tree as their highest level and 26 passed the formal level of equilateral triangle as their

TABLE 27

PERCENTAGE OF STUDENTS IN COMBINED FIRST, FOURTH, AND SEVENTH GRADES WHO PASSED EACH OF TEN TASKS BASED ON PIAGETIAN THEORY ACCORDING TO HIGHEST LEVEL OF ATTAINMENT OF THE CONCEPTS TREE, EQUILATERAL TRIANGLE, AND NOUN

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task		
		Tree	Equilateral Triangle	Noun
None		n = 1	n = 2	n = 15
	0%-25%	Prim Add of Class (0%)		Prim Add of Class (0%)
			Sec Add of Class (0%)	Sec Add of Class (20%)
		Bi-univ Mult of Class (0%)	Bi-univ Mult of Class (0%)	Bi-univ Mult of Class (20%)
		Co-univ Mult of Class (0%)	Co-univ Mult of Class (0%)	
		Add of Asym Rel (0%)		
		Bi-univ Mult of Rel (0%)		
		Co-univ Mult of Rel (0%)	Co-univ Mult of Rel (0%)	
		Class Incl (0%)		
		Comb Reas (0%)	Comb Reas (0%)	Comb Reas (0%)
	26%-50%		Prim Add of Class (50%)	
				Co-univ Mult of Class (27%)
			Add of Asym Rel (50%)	
			Add of Sym Rel (50%)	
			Bi-univ Mult of Rel (50%)	Bi-univ Mult of Rel (47%)
				Co-univ Mult of Rel (27%)
			Class Incl (50%)	Class Incl (27%)
	51%-75%			Add of Asym Rel (67%)
				Add of Sym Rel (73%)
	76%-100%	Sec Add of Class (100%)		
		Add of Sym Rel (100%)		

TABLE 27, continued.

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task: Tree	CLD Task: Equilateral Triangle	CLD Task: Noun
Concrete		n = 1	n = 2	n = 22
	0%-25%	Comb Reas (0%) Prim Add of Class (0%) Sec Add of Class (0%)	Comb Reas (0%)	Comb Reas (5%) Prim Add of Class (9%) Bi-univ Mult of Class (18%) Co-univ Mult of Class (23%) Class Incl (23%)
	26%-50%		Prim Add of Class (50%) Sec Add of Class (50%) Co-univ Mult of Class (50%) Class Incl (50%)	Sec Add of Class (27%)
	51%-75%			Co-univ Mult of Rel (55%) Bi-univ Mult of Rel (64%)
	76%-100%	Bi-univ Mult of Class (100%) Co-univ Mult of Class (100%) Class Incl (100%) Add of Asym Rel (100%) Add of Sym Rel (100%) Bi-univ Mult of Rel (100%) Co-univ Mult of Rel (100%)	Bi-univ Mult of Class (100%) Add of Asym Rel (100%) Add of Sym Rel (100%) Bi-univ Mult of Rel (100%) Co-univ Mult of Rel (100%)	Add of Asym Rel (82%) Add of Sym Rel (77%)
Identity		n = 31	n = 29	n = 79
	0%-25%	Comb Reas (6%) Prim Add of Class (13%) Bi-univ Mult of Class (13%) Sec Add of Class (23%)	Comb Reas (24%)	Bi-univ Mult of Class (16%) Sec Add of Class (25%)
	26%-50%	Co-univ Mult of Class (26%) Class Incl (32%)	Bi-univ Mult of Class (28%) Prim Add of Class (31%) Sec Add of Class (31%) Co-univ Mult of Class (48%) Class Incl (41%)	Comb Reas (28%) Prim Add of Class (29%)

TABLE 27, continued.

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task		
		Tree	Equilateral Triangle	Noun
	51%-75%	Bi-univ Mult of Rel (61%) Co-univ Mult of Rel (65%)	Bi-univ Mult of Rel (72%) Co-univ Mult of Rel (66%)	Class Incl (51%) Co-univ Mult of Class (52%) Co-univ Mult of Rel (71%)
	76%-100%	Add of Sym Rel (77%) Add of Asym Rel (90%)	Add of Sym Rel (90%) Add of Asym Rel (79%)	Add of Sym Rel (91%) Add of Asym Rel (80%) Bi-univ Mult of Rel (77%)
Classificatory		n = 86	n = 94	n = 38
	0%-25%	Bi-univ Mult of Class (17%) Comb Reas (24%)	Bi-univ Mult of Class (12%) Comb Reas (19%) Prim Add of Class (19%)	
	26%-50%	Prim Add of Class (28%) Sec Add of Class (30%) Class Incl (48%)	Sec Add of Class (26%) Class Incl (44%) Co-univ Mult of Class (46%)	Bi-univ Mult of Class (37%) Comb Reas (47%)
	51%-75%	Co-univ Mult of Class (51%) Co-univ Mult of Rel (64%)	Co-univ Mult of Rel (64%) Bi-univ Mult of Rel (72%)	Prim Add of Class (61%) Sec Add of Class (66%) Class Incl (71%)
	76%-100%	Bi-univ Mult of Rel (78%) Add of Asym Rel (80%) Add of Sym Rel (91%)	Add of Asym Rel (79%) Add of Sym Rel (87%)	Co-univ Mult of Class (84%) Co-univ Mult of Rel (87%) Bi-univ Mult of Rel (92%) Add of Asym Rel (89%) Add of Sym Rel (100%)

TABLE 27, continued.

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task		
		Tree	Equilateral Triangle	Noun
Formal		n = 34	n = 26	n = 2
	0%-25%			
	26%-50%	Bi-univ Mult of Class (44%)	Bi-univ Mult of Class (50%)	Comb Reas (50%)
	51%-75%	Comb Reas (53%) Prim Add of Class (62%) Sec Add of Class (62%) Class Incl (74%)	Comb Reas (62%) Prim Add of Class (73%)	
	76%-100%		Sec Add of Class (77%) Class Incl (81%)	Sec Add of Class (100%) Class Incl (100%)
		Add of Asym Rel (82%) Co-univ Mult of Rel (88%) Co-univ Mult of Class (88%) Bi-univ Mult of Rel (91%) Add of Sym Rel (100%)	Add of Asym Rel (92%) Co-univ Mult of Rel (88%) Co-univ Mult of Class (88%) Bi-univ Mult of Rel (92%) Add of Sym Rel (100%)	Add of Asym Rel (100%) Co-univ Mult of Rel (100%) Co-univ Mult of Class (100%) Bi-univ Mult of Rel (100%) Add of Sym Rel (100%) Bi-univ Mult of Class (100%) Prim Add of Class (100%)

highest level. Fifty-one percent or more of these students mastered all the Piagetian tasks except Bi-univocal Multiplication of Classes; here the percentages passing were 44 and 50 for tree and equilateral triangle. Despite this close correspondence, there is a tendency for a higher percent of the students who passed equilateral triangle at any given level, in comparison with tree, to also pass more of the Piagetian tasks.

Inasmuch as noun is the latest concept of the three to be mastered at the various levels, we would also expect that for each respective level, a higher percent of the students would pass the Piagetian tasks. It is noted that 51 percent or more of the students who passed the identity level of noun mastered six of the Piagetian tasks, all except Bi-univocal Multiplication of Classes, Secondary Addition of Classes, Combinatorial Reasoning, and Primary Addition of Classes. Of those students who passed the classificatory level of noun, 51 percent or more passed eight of the Piagetian tasks, all except Bi-univocal Multiplication of Classes and Combinatorial Reasoning. The 38 students passing the classificatory level of noun as their highest performed about as well on the Piagetian tasks as did the 34 students passing the formal level of tree.

PERCENTAGE OF STUDENTS IN COMBINED FIRST, FOURTH, AND SEVENTH GRADES WHO PASSED THE CLD USES OF TREE, EQUILATERAL TRIANGLE, AND NOUN AND WHO ALSO PASSED EACH OF TEN PIAGETIAN TASKS

Table 28 gives the numbers of students passing each of the three different uses for each of the three different concepts. It is observed that these numbers range from 2 through 17. These numbers are regarded as being too small to merit drawing any conclusions. It may be noted that

TABLE 28

PERCENTAGE OF STUDENTS IN COMBINED FIRST, FOURTH, AND SEVENTH GRADES WHO PASSED EACH CLD USE OF TREE, EQUILATERAL TRIANGLE, AND NOUN AND WHO ALSO PASSED EACH OF TEN TASKS BASED ON PIAGETIAN THEORY

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task		
		Tree	Equilateral Triangle	Noun
Taxonomic Relationships		n = 14	n = 17	n =
	0%-25%	Bi-univ Mult of Class (21%)		
	26%-50%	Sec Add of Class (29%) Comb Reas (29%) Prim Add of Class (36%)	Sec Add of Class (35%) Comb Reas (41%) Prim Add of Class (29%) Bi-univ Mult of Class (35%)	Comb Reas (%)
	51%-75%	Class Incl (57%) Co-univ Mult of Class (71%)	Class Incl (59%) Co-univ Mult of Class (65%)	Bi-univ Mult of Class (67%) Add of Asym Rel (67%) Bi-univ Mult of Rel (67%)
	76%-100%	Co-univ Mult of Rel (79%) Add of Asym Rel (86%) Bi-univ Mult of Rel (86%) Add of Sym Rel (100%)	Co-univ Mult of Rel (88%) Add of Asym Rel (76%) Bi-univ Mult of Rel (82%) Add of Sym Rel (100%)	Co-univ Mult of Rel (100%) Add of Sym Rel (100%) Prim Add of Class (100%) Sec Add of Class (100%) Co-univ Mult of Class (100%) Class Incl (100%)

TABLE 28, continued.

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task		
		Tree	Equilateral Triangle	Noun
Principle		n = 8	n = 11	n = 2
	0%-25%			
	26%-50%	Comb Reas (38%) Bi-univ Mult of Class (50%)		Bi-univ Mult of Class (50%)
	51%-75%	Sec Add of Class (63%)	Bi-univ Mult of Class (55%) Comb Reas (64%) Prim Add of Class (73%) Class Incl (73%)	
	76%-100%	Prim Add of Class (88%) Class Incl (88%) Add of Asym Rel (88%) Co-univ Mult of Class (100%) Add of Sym Rel (100%) Bi-univ Mult of Rel (100%) Co-univ Mult of Rel (100%)	Sec Add of Class (82%) Add of Asym Rel (100%) Co-univ Mult of Class (91%) Add of Sym Rel (100%) Bi-univ Mult of Rel (91%) Co-univ Mult of Rel (91%)	Sec Add of Class (100%) Prim Add of Class (100%) Class Incl (100%) Add of Asym Rel (100%) Co-univ Mult of Class (100%) Add of Sym Rel (100%) Bi-univ Mult of Rel (100%) Co-univ Mult of Rel (100%) Bi-univ Mult of Class (100%) Comb Reas (100%)

TABLE 28, continued.

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task: Tree	Equilateral Triangle	Noun
Problem Solving		n = 3	n = 9	n = 8
	0%-25%	Comb Reas (0%)		
	26%-50%	Prim Add of Class (33%) Bi-univ Mult of Class (33%)	Bi-univ Mult of Class (44%)	Bi-univ Mult of Class (38%) Comb Reas (50%)
	51%-75%	Sec Add of Class (67%) Add of Asym Rel (67%)	Prim Add of Class (56%) Sec Add of Class (67%) Class Incl (67%) Comb Reas (67%)	Prim Add of Class (63%) Sec Add of Class (63%) Class Incl (75%) Co-univ Mult of Class (75%)
	76%-100%	Co-univ Mult of Class (100%) Class Incl (100%) Add of Sym Rel (100%) Bi-univ Mult of Rel (100%) Co-univ Mult of Rel (100%)	Co-univ Mult of Class (78%) Add of Sym Rel (100%) Bi-univ Mult of Rel (78%) Co-univ Mult of Rel (78%) Add of Asym Rel (78%)	Add of Sym Rel (100%) Bi-univ Mult of Rel (88%) Co-univ Mult of Rel (88%) Add of Asym Rel (100%)

the results of the interval data dealing with the concept uses will be reported in a later part of this chapter.

PERCENTAGE OF STUDENTS IN COMBINED FIRST AND FOURTH GRADES WHO PASSED EACH CLD LEVEL OF TREE, EQUILATERAL TRIANGLE, AND NOUN AND WHO ALSO PASSED EACH OF 14 PIAGETIAN TASKS

Table 29 presents information regarding the number of students who passed no CLD level and each of the four successive levels of attainment of the concepts tree, equilateral triangle, and noun. The respective numbers of students at no level are 1, 2, and 15, at the concrete level are 1, 2, and 22, and at the formal level are 7, 3, and 0, respectively. Because of these low numbers no other information is presented regarding these levels.

Table 29 shows that the numbers of students passing the identity and classificatory levels of tree and equilateral triangle as their highest level of attainment are very close. Similarly the patterns of passing the Piagetian tasks correspond quite closely. Fifty-one percent or more of the students who passed the identity level of tree also mastered seven Piagetian tasks--Transitivity of Weight, Serial Matching, Some-all, Transitivity of Length, Seriation Construction, Seriation Addition, and Equivalence Conservation of Length. The same Piatetian tasks were mastered by 51 percent or more of the students who attained the classificatory level of equilateral triangle. In addition, these students mastered Conservation of Number and Identity Conservation of Weight.

Students who passed the classificatory level of tree and equilateral triangle as their highest levels performed about the same with respect to the Piagetian tasks. Fifty-one percent or more of the students passing either the classificatory level of tree or of equilateral triangle passed at least 12 of the 14 Piagetian tasks.

TABLE 29

PERCENTAGE OF STUDENTS IN COMBINED FIRST AND FOURTH GRADES WHO PASSED EACH OF 14 PIAGETIAN TASKS ACCORDING TO HIGHEST LEVEL OF ATTAINMENT OF THE CONCEPTS TREE, EQUILATERAL TRIANGLE, AND NOUN

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task: Tree	CLD Task: Equilateral Triangle	CLD Task: Noun
None		n = 1	n = 2	n = 15
	0%-25%	Ser Ext-Comp (0%) Ser Scr (0%) Dich (0%) Some-all (0%) Cons of No. (0%) Id Cons of Lgth (0%) Eq Cons of Lgth (0%) Eq Cons of Wgt (0%)	Ser Ext-Comp (0%) Trans of Lgth (0%) Cons of No. (0%) Id Cons of Lgth (0%) Eq Cons of Lgth (0%)	Ser Ext-Comp (20%) Ser Scr (20%)
	26%-50%		Ser Scr (50%) Trans of Wgt (50%) Dich (50%) Id Cons of Wgt (50%) Eq Cons of Wgt (50%)	Dich (27%) Id Cons of Wgt (27%) Eq Cons of Wgt (33%) Id Cons of Lgth (33%) Cons of No. (33%) Eq Cons of Lgth (40%)
	51%-75%			Trans of Lgth (53%) Ser Const (67%) Some-all (67%) Ser Add (80%) Ser Match (87%) Trans of Weight (93%)
	76%-100%	Ser Const (100%) Ser Add (100%) Ser Match (100%) Trans of Lgth (100%) Trans of Wgt (100%) Id Cons of Wgt (100%)	Some-all (100%) Ser Const (100%) Ser Add (100%) Ser Match (100%)	

TABLE 29, continued.

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task		
		Tree	Equilateral Triangle	Noun
Concrete		n = 1	n = 2	n = 22
	0%-25%	Trans of Lgth (0%)		Dich (14%) Ser Ext-Comp (23%)
	26%-50%		Ser Const (50%) Ser Add (50%) Ser Ext-Comp (50%) Ser Scr (50%) Trans of Lgth (50%) Dich (50%) Cons of No. (50%)	Ser Scr (27%) Eq Cons of Wgt (45%) Id Cons of Lgth (50%)
	51%-75%			Eq Cons of Lgth (55%) Id Cons of Wgt (55%) Some-all (68%) Cons of No. (68%) Trans of Lgth (73%)
	76%-100%	Ser Const (100%) Ser Add (100%) Ser Match (100%) Ser Ext-Comp (100%) Ser Scr (100%) Trans of Wgt (100%) Dich (100%) Some-all (100%) Cons of No. (100%) Id Cons of Lgth (100%) Eq Cons of Lgth (100%) Id Cons of Wgt (100%) Eq Cons of Wgt (100%)	Ser Match (100%) Trans of Wgt (100%) Some-all (100%) Id Cons of Lgth (100%) Eq Cons of Lgth (100%) Id Cons of Wgt (100%) Eq Cons of Wgt (100%)	Ser Const (86%) Ser Add (91%) Ser Match (100%) Trans of Wgt (91%)

TABLE 29, continued.

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task: Tree	CLD Task: Equilateral Triangle	CLD Task: Noun
Identity		n = 22	n = 24	n = 56
	0%-25%			
	26%-50%	Ser Scr (27%) Ser Ext-Comp (32%) Dich (32%) Id Cons of Lgth (41%) Id Cons of Wgt (41%) Eq Cons of Wgt (41%) Cons of No. (50%)	Ser Scr (46%) Ser Ext-Comp (42%) Dich (42%) Id Cons of Lgth (42%) Eq Cons of Lgth (50%)	Ser Scr (45%)
	51%-75%	Eq Cons of Lgth (59%) Ser Add (68%) Ser Const (73%) Trans of Lgth (73%)	Id Cons of Wgt (58%) Eq Cons of Wgt (58%) Some-all (67%) Cons of No. (75%)	Ser Ext-Comp (59%) Dich (70%)
	76%-100%	Some-all (77%) Ser Match (91%) Trans of Wgt (91%)	Trans of Lgth (83%) Ser Match (92%) Trans of Wgt (92%) Ser Const (92%) Ser Add (92%)	Some-all (88%) Ser Match (100%) Trans of Wgt (95%) Trans of Lgth (88%) Ser Const (100%) Ser Add (95%) Eq Cons of Lgth (77%) Eq Cons of Wgt (77%) Id Cons of Lgth (79%) Id Cons of Wgt (82%) Cons of No. (84%)

TABLE 29, continued.

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task		
		Tree	Equilateral Triangle	Noun
Classificatory		n = 68	n = 69	n = 9
	0%-25%			
	26%-50%	Ser Scr (43%)	Ser Scr (38%) Ser Ext-Comp (48%)	
	51%-75%	Ser Ext-Comp (51%) Dich (59%) Eq Cons of Lgth (69%) Id Cons of Lgth (72%) Eq Cons of Wgt (72%)	Dich (55%) Eq Cons of Lgth (74%) Id Cons of Lgth (72%) Eq Cons of Wgt (65%) Id Cons of Wgt (71%) Cons of No. (75%)	Ser Scr (67%)
	76%-100%	Id Cons of Wgt (76%) Cons of No. (81%) Trans of Lgth (82%) Some-all (84%) Trans of Wgt (96%) Ser Const (97%) Ser Add (99%) Ser Match (100%)	Trans of Lgth (81%) Some-all (84%) Trans of Wgt (94%) Ser Const (92%) Ser Add (93%) Ser Match (100%)	Cons of No. (78%) Trans of Lgth (100%) Some-all (100%) Trans of Wgt (89%) Ser Const (100%) Ser Add (100%) Ser Match (100%) Ser Ext-Comp (78%) Id Cons of Lgth (78%) Eq Cons of Lgth (89%) Id Cons of Wgt (89%) Eq Cons of Wgt (89%) Dich (100%)

TABLE 29, continued.

Highest CLD level Passed	Percentage Ranges Passing Piagetian Task	CLD Task		
		Tree	Equilateral Triangle	Noun
Formal		n = 7	n = 3	n = 0
	0%-25%		Ser Scr (0%)	
	26%-50%	Ser Ext-Comp (43%) Ser Scr (43%)		
	51%-75%	Cons of No. (71%)	Cons of No. (67%) Ser Ext-Comp (67%) Eq Cons of Lgth (67%) Id Cons of Wgt (67%) Eq Cons of Wgt (67%)	
	76%-100%	Trans of Wgt (86%) Dich (86%) Some-all (86%) Id Cons of Wgt (86%) Eq Cons of Wgt (86%) Ser Const (100%) Ser Add (100%) Ser Match (100%) Trans of Lgth (100%) Id Cons of Lgth (100%) Eq Cons of Lgth (100%)	Trans of Wgt (100%) Dich (100%) Some-all (100%) Ser Const (100%) Ser Add (100%) Ser Match (100%) Trans of Lgth (100%) Id Cons of Lgth (100%)	

Seventy-six percent or more of the students who passed the identity level of noun as their highest also passed 11 of the 14 Piagetian tasks, and 76 percent or more who passed the classificatory level of noun mastered all except one of the Piagetian tasks, Seriation Scrambled Case. It has been noted earlier the nature of the examples and nonexamples of noun along with the means used in measuring the identity level may have contributed to the ability of students who passed the identity level of noun also to be able to pass the Piagetian tests.

The numbers of first- and fourth-grade students passing the various uses of each of the concepts tree, equilateral triangle, and noun were very low, lower than that shown in prior Table 28 that also included seventh-grade students; therefore, tabular data are not presented regarding uses for students in only grades one and four combined.

CORRELATIONAL RESULTS FOR COMBINED FIRST, FOURTH, AND SEVENTH GRADES INVOLVING LEVEL OF ATTAINMENT SCORE AND EACH OF THREE USES SCORES FOR EQUILATERAL TRIANGLE, NOUN, AND TREE, TEN PIAGETIAN TASK SCORES AND THREE MEMORY SCORES

The tests treated according to an interval scoring system and administered to the subjects enrolled in grades one, four, and seven in the second assessment year included a combined level of attainment score and three uses scores for each CLD battery: equilateral triangle, noun, and tree, a total of 12 tests. There were two traditional Piagetian tasks, namely, Class Inclusion and Combinatorial Reasoning. The *groupements* task battery includes eight subtasks each to measure a different aspect of classificatory or relational understanding. Three memory test scores were also obtained, namely, auditory memory span (word series), auditory sequential memory (digit series), and visual orientation memory.

Table 30 presents the means and standard deviations for the combined first, fourth, and seventh grades on each of the preceding tests. The means and standard deviations are not discussed further inasmuch as they have been treated in detail in other technical reports by separate grade levels (Hooper, Swinton, & Sipple, 1976; Klausmeier, Allen, Sipple, & White, 1975).

Table 31 presents the correlation matrix involving the set of 25 test scores for the 156 students. This correlation matrix was submitted to factor analysis. In Table A-1 of Appendix A, the raw factor matrix is reported.

Table 32 presents the results of the rotated factor matrix (principle components using the varimax procedure) for combined grades one, four, and seven. The loadings for all the variables are presented and the rank orders of the loadings are given for all loadings .30 or greater.

The first factor accounting for about 32 percent of the total variance may be designated a "cognitive development" factor. Significant loadings on this factor were shown by all 12 of the CLD battery tests, Combinatorial Reasoning, and visual orientation memory.

The second factor may be designated "addition and multiplication of classes." The tests loading on this factor are the special *groupement* tasks dealing with the addition and multiplication of classes and also the traditional Piagetian task of Class Inclusion.

The third factor may be designated "addition and multiplication of relations." The four *groupement* tasks designed to measure the addition and multiplication of relations loaded on this factor as did Class Inclusion and Co-univocal Multiplication of Classes.

TABLE 30

MEANS AND STANDARD DEVIATIONS ON LEVEL OF ATTAINMENT AND EACH OF THREE USES FOR EQUILATERAL TRIANGLE, NOUN, AND TREE TASKS, TEN TASKS BASED ON PIAGETIAN THEORY, AND THREE MEMORY TESTS FOR COMBINED FIRST, FOURTH, SEVENTH GRADES (N = 156)

Task	Total Items	Mean	Standard Deviation
Total levels of Eq. Tri.	37	28.47	4.54
Sup-Sub for Eq. Tri.	8	3.86	1.80
Prin for Eq. Tri.	11	3.95	3.37
Prob Solv for Eq. Tri.	6	1.86	1.64
Total levels of Noun	49	25.59	10.46
Sup-Sub for Noun	8	2.32	2.02
Prin for Noun	10	2.62	2.49
Prob Solv for Noun	5	1.15	1.29
Total levels of Tree	59	44.16	7.96
Sup-Sub for Tree	8	3.72	1.82
Prin for Tree	20	6.89	5.62
Prob Solv for Tree	10	2.99	1.81
Prim Add of Class	8	5.61	1.60
Sec Add of Class	8	5.81	1.64
Bi-univ Mult of Class	8	4.36	2.27
Co-univ Mult of Class	8	5.87	2.37
Class Incl	5	4.00	1.24
Comb Reas	28	21.72	7.91
Add of Asym Rel	8	7.37	1.15
Add of Sym Rel	8	7.56	1.19
Bi-univ Mult of Rel	8	6.91	1.67
Co-univ Mult of Rel	8	6.80	1.50
Aud Seq Mem	70	34.30	14.30
Aud Mem Span	60	36.20	10.78
Visual Mem	20	15.46	3.82

TABLE 31

INTERCORRELATIONS AMONG 25 VARIABLES FOR THE COMBINED FIRST, FOURTH, AND SEVENTH GRADES FOR THE YEAR TWO ASSESSMENTS

	Variables	1	2	3	4	5	6	7	8	9	10	11	12
1	Total levels of Eq. Tri.	1.00											
2	Sup-Sub for Eq. Tri.	.550											
3	Prin for Eq. Tri.	.683	.510										
4	Prob Solv for Eq. Tri.	.671	.536	.779									
5	Total levels of Noun	.713	.564	.813	.765								
6	Sup-Sub for Noun	.591	.471	.720	.644	.822							
7	Prin for Noun	.635	.527	.764	.696	.838	.740						
8	Prob Solv for Noun	.493	.424	.662	.544	.704	.685	.751					
9	Total levels of Tree	.668	.494	.679	.633	.733	.608	.671	.574				
10	Sup-Sub for Tree	.527	.458	.664	.562	.698	.625	.602	.552	.705			
11	Prin for Tree	.692	.531	.788	.723	.825	.753	.739	.612	.777	.710		
12	Prob Solv for Tree	.535	.352	.498	.478	.519	.386	.531	.377	.540	.507	.605	
13	Prim Add of Class	.402	.188	.484	.404	.467	.414	.381	.342	.430	.311	.452	.154
14	Sec Add of Class	.381	.126	.401	.360	.391	.373	.351	.295	.335	.310	.352	.156
15	Bi-univ Mult of Class	.237	.202	.312	.256	.303	.263	.286	.238	.312	.241	.368	.100
16	Co-univ Mult of Class	.385	.253	.402	.334	.443	.378	.377	.363	.342	.310	.444	.174
17	Class Incl	.384	.249	.392	.367	.439	.346	.341	.283	.302	.286	.369	.129
18	Comb Reas	.310	.269	.407	.346	.423	.375	.357	.371	.305	.367	.429	.098
19	Add of Asym Rel	.194	.084	.209	.130	.165	.070	.081	.092	.121	.147	.101	.072
20	Add of Sym Rel	.302	.184	.286	.265	.291	.230	.252	.217	.315	.250	.295	.223
21	Bi-univ Mult of Rel	.185	.056	.242	.200	.277	.204	.237	.184	.213	.193	.216	.115
22	Co-univ Mult of Rel	.329	.193	.419	.282	.389	.319	.322	.301	.275	.264	.338	.192
23	Aud Seq Mem	.166	.121	.245	.159	.253	.195	.148	.201	.210	.203	.224	.051
24	Aud Mem Span	.322	.199	.312	.271	.360	.344	.202	.275	.310	.283	.328	.092
25	Visual Mem	.494	.366	.553	.467	.590	.517	.468	.467	.449	.514	.540	.353

TABLE 31, continued.

Variables	13	14	15	16	17	18	19	20	21	22	23	24	25
13 Prim Add of Class	1.000												
14 Sec Add of Class	.774												
15 Bi-univ Mult of Class	.507	.544											
16 Co-univ Mult of Class	.503	.488	.431										
17 Class Incl	.412	.336	.335	.464									
18 Comb Reas	.275	.213	.307	.339	.288								
19 Add of Asym Rel	.082	.143	.185	.223	.199	.096							
20 Add of Sym Rel	.210	.069	.154	.229	.310	.308	.161						
21 Bi-univ Mult of Rel	.208	.186	.279	.234	.330	.193	.322	.129					
22 Co-univ Mult of Rel	.317	.205	.253	.396	.421	.327	.275	.316	.419				
23 Aud Seq Mem	.324	.313	.267	.385	.305	.274	.058	.157	.197	.322			
24 Aud Mem Span	.297	.284	.200	.260	.260	.199	.166	.180	.146	.235	.615		
25 Visual Mem	.411	.330	.258	.355	.349	.390	.046	.259	.219	.282	.316	.321	1.00

Value of correlation coefficient significant at the .05 level = .159, and at the .01 level = .208 (two-tailed probabilities).

TABLE 32

ROTATED FACTOR MATRIX (PRINCIPAL COMPONENTS ANALYSIS UTILIZING VARIMAX PROCEDURES) FOR THE COMBINED FIRST, FOURTH, AND SEVENTH GRADE SAMPLE FOR THE YEAR 2 ASSESSMENTS (RANK ORDERING OF VARIABLES LOADING (≥ .30) ON THE RESPECTIVE FACTORS ARE PRESENTED IN PARENTHESES)

	FACTORS			
Variables	1	2	3	4
Total levels of Eq. Tri.	.745 (9)	.190	.196	.101
Sup-Sub for Eq. Tri.	.657 (12)	-.009	.061	.105
Prin for Eq. Tri.	.813 (4)	.244	.219	.139
Prob Solv for Eq. Tri	.788 (5)	.201	.137	.068
Total levels of Noun	.863 (1)	.224	.196	.182
Sup-Sub for Noun	.780 (7)	.221	.074	.190
Prin for Noun	.845 (3)	.200	.132	.024
Prob Solv for Noun	.717 (10)	.159	.094	.169
Total levels of Tree	.788 (6)	.191	.119	.114
Sup-Sub for Tree	.752 (8)	.109	.120	.158
Prin for Tree	.852 (2)	.228	.137	.148
Prob Solv for Tree	.687 (11)	-.043	.085	-.107
Prim Add of Class	.280	.808 (2)	.079	.185
Sec Add of Class	.213	.872 (1)	.016	.112
Bi-univ Mult of Class	.137	.704 (3)	.237	.068
Co-univ Mult of Class	.250	.548 (4)	.325 (6)	.258
Class Incl	.236	.345 (5)	.485 (4)	.252
Comb Reas	.336 (14)	.138	.283	.354 (4)
Add of Asym Rel	.023	.074	.685 (1)	-.093
Add of Sym Rel	.266	-.085	.448 (5)	.248
Bi-univ Mult of Rel	.087	.181	.685 (2)	.014
Co-univ Mult of Rel	.215	.131	.670 (3)	.254
Aud Seq Mem	.032	.234	.117	.837 (1)
Aud Mem Span	.194	.122	.064	.788 (2)
Visual Mem	.544 (13)	.211	.104	.369 (3)
Percentage of total Factor Variance	52.2	19.0	15.1	13.7
Percentage of total Variance	32.3	11.7	9.3	8.5

The fourth factor may be designated a "memory" factor. Loading on this factor were the three short-term memory tests and Combinatorial Reasoning.

These factors appear to be quite clearly defined by the various tests used with these particular students involving three different grade levels. The grade levels were combined in order to examine the performances of a reasonable number of subjects. The factor patterns, therefore, should not be interpreted as inclusive for those patterns at each grade level. The numbers of subjects at each grade level, however, were considered too small to arrive at any useful information from factor analysis according to grade level.

CORRELATIONAL RESULTS FOR COMBINED FIRST AND FOURTH GRADES INVOLVING LEVEL OF ATTAINMENT SCORE AND EACH OF THREE USES SCORES FOR EQUILATERAL TRIANGLE, NOUN, AND TREE, TWENTY-ONE PIAGETIAN TASK SCORES, THREE MEMORY TEST SCORES AND AN ARITHMETIC ADDITION SCORE

It will be recalled that most of the traditional Piagetian tasks were not administered to the sixth grade students on the assumption that they would pass the tasks. In contrast, the first and fourth subjects received a more extensive array of Piagetian logical concept tasks.

Table 33 presents the means and standard deviations for the 102 combined first and fourth grade students for each of the 37 tests. These separate grade-level results are discussed in detail in other technical reports (Hooper, Swinton, & Sipple, 1976; Klausmeier, Allen, Sipple, & White, 1975).

Table 34 presents the correlation matrix for the combined first and fourth grades involving the 37 tests. This matrix was submitted to factor

TABLE 33

MEANS AND STANDARD DEVIATIONS ON LEVEL OF ATTAINMENT AND EACH OF THREE USES FOR EQUILATERAL TRIANGLE, NOUN, AND TREE TASKS, 21 TASKS BASED ON PIAGETIAN THEORY, THREE MEMORY TESTS, AND ARITHMETIC ADDITION TASK FOR COMBINED FIRST AND FOURTH GRADES (N = 102)

Task	Total Items	Mean	Standard Deviation
Total levels of Eq. Tri.	37	26.66	3.96
Sup-Sub for Eq. Tri.	8	3.40	1.64
Prin for Eq. Tri.	11	2.35	2.64
Prob Solv for Eq. Tri.	6	1.21	1.39
Total levels of Noun	49	20.72	9.00
Sup-Sub for Noun	8	1.43	1.65
Prin for Noun	10	1.43	1.79
Prob Solv for Noun	5	0.60	0.94
Total levels of Tree	59	41.51	6.92
Sup-Sub for Tree	8	3.12	1.65
Prin for Tree	20	4.69	5.00
Prob Solv for Tree	10	2.50	1.61
Prim Add of Class	8	5.25	1.50
Sec Add of Class	8	5.42	1.56
Bi-univ Mult of Class	8	4.01	2.23
Co-univ Mult of Class	8	5.37	2.40
Class Incl	5	3.75	1.25
Comb Reas	28	20.18	8.46
Add of Asym Rel	8	7.24	1.28
Add of Sym Rel	8	7.38	1.41
Bi-univ Mult of Rel	8	6.79	1.67
Co-univ Mult of Rel	8	6.49	1.61
Aud Seq Mem	70	33.19	15.55
Aud Mem Span	60	33.54	11.06
Visual Mem	20	14.26	4.01
Dich	3	2.29	0.90
Some-all	4	3.77	0.51
Cardinal	5	3.52	1.19
Trans of Lgth	5	4.32	1.58
Trans of Wgt	5	4.76	0.95
Seriation	5	3.69	1.10
Cons of No.	7	6.18	1.68
Id Cons of Lgth	6	4.86	1.67
Eq Cons of Lgth	6	4.52	2.33
Id Cons of Wgt	6	4.94	1.67
Eq Cons of Wgt	6	4.48	2.38
Arith Add	16	14.79	2.56

TABLE 34

INTERCORRELATIONS AMONG 37 VARIABLES FOR THE COMBINED FIRST AND FOURTH GRADES FOR THE YEAR 2 ASSESSMENTS

Variables		1	2	3	4	5	6	7	8	9	10	11	12
1	Total levels of Eq. Tri.	1.000											
2	Sup-Sub for Eq. Tri.	.485											
3	Prin for Eq. Tri.	.510	.451										
4	Prob Solv for Eq. Tri.	.581	.510	.765									
5	Total levels of Noun	.587	.570	.778	.763								
6	Sup-Sub for Noun	.491	.498	.669	.687	.808							
7	Prin for Noun	.508	.515	.719	.719	.798	.719						
8	Prob Solv for Noun	.259	.312	.574	.537	.635	.639	.629					
9	Total levels of Tree	.572	.418	.628	.612	.667	.568	.548	.423				
10	Sup-Sub for Tree	.408	.390	.586	.571	.673	.590	.426	.402	.591			
11	Prin for Tree	.614	.486	.746	.738	.789	.737	.631	.484	.671	.636		
12	Prob Solv for Tree	.434	.290	.335	.357	.429	.280	.391	.122	.347	.402	.446	
13	Prim Add of Class	.268	.175	.369	.336	.318	.279	.227	.243	.324	.215	.346	-.033
14	Sec Add of Class	.178	.014	.194	.221	.154	.191	.122	.145	.147	.192	.151	-.101
15	Bi-univ Mult of Class	.050	.102	.152	.127	.100	.169	.081	.087	.098	.061	.230	-.115
16	Co-univ Mult of Class	.288	.243	.357	.235	.344	.312	.270	.332	.326	.303	.420	.079
17	Class Incl	.320	.229	.412	.373	.375	.265	.253	.250	.287	.269	.348	.054
18	Comb Reas	.153	.185	.302	.230	.326	.295	.230	.288	.162	.274	.363	-.043
19	Add of Asym Rel	.126	.039	.122	.067	.050	-.035	-.036	.014	.079	.071	.015	.077
20	Add of Sym Rel	.236	.163	.197	.191	.208	.136	.165	.110	.290	.201	.238	.163
21	Bi-univ Mult of Rel	.135	.110	.271	.190	.277	.209	.232	.207	.257	.213	.205	.031
22	Co-univ Mult of Rel	.193	.086	.315	.145	.247	.166	.156	.191	.172	.194	.242	.019
23	Aud Seq Mem	.086	.073	.303	.154	.211	.155	.048	.183	.212	.211	.251	.027
24	Aud Mem Span	.235	.162	.215	.171	.219	.175	-.001	.162	.315	.281	.284	.057
25	Visual Mem	.343	.345	.429	.369	.495	.412	.321	.306	.353	.462	.469	.291
26	Dich	.405	.363	.428	.420	.549	.476	.357	.319	.388	.437	.475	.178
27	Some-all	.164	.229	.268	.250	.288	.189	.174	.183	.277	.269	.265	.176
28	Cardinal	.340	.327	.384	.360	.469	.348	.311	.287	.460	.380	.491	.343
29	Trans of Lgth	.220	.201	.328	.249	.354	.299	.275	.276	.263	.390	.273	.177
30	Trans of Wgt	.065	.061	.152	.045	.116	.129	.107	.116	-.006	.024	.147	-.033
31	Seriation	.286	.219	.468	.315	.482	.441	.305	.242	.398	.478	.441	.252
32	Cons of No.	.311	.261	.329	.286	.485	.372	.300	.222	.438	.413	.351	.319
33	Id Cons of Lgth	.355	.226	.323	.251	.322	.230	.172	.211	.272	.235	.299	.144
34	Eq Cons of Lgth	.337	.157	.271	.276	.260	.212	.128	.219	.203	.184	.296	.099
35	Id Cons of Wgt	.274	.261	.335	.197	.274	.228	.147	.035	.201	.239	.301	.129
36	Eq Cons of Wgt	.290	.206	.356	.209	.259	.239	.176	-.015	.245	.279	.283	.058
37	Arith Add	.306	.296	.340	.308	.463	.286	.253	.205	.365	.399	.310	.340

TABLE 34, continued.

Variables	13	14	15	16	17	18	19	20	21	22	23	24	25
13 Prim Add of Class	1.000												
14 Sec Add of Class	.725												
15 Bi-univ Mult of Class	.494	.507											
16 Co-univ Mult of Class	.479	.400	.459										
17 Class Incl	.426	.249	.293	.293									
18 Comb Reas	.217	.117	.191	.365	.261								
19 Add of Asym Rel	.015	.029	.107	.155	.125	.006							
20 Add of Sym Rel	.150	-.015	.109	.232	.336	.271	.147						
21 Bi-univ Mult of Rel	.207	.102	.286	.178	.369	.119	.316	.109					
22 Co-univ Mult of Rel	.194	.019	.184	.375	.423	.265	.242	.269	.403				
23 Aud Seq Mem	.277	.243	.309	.379	.289	.302	.068	.159	.245	.320			
24 Aud Mem Span	.233	.130	.139	.189	.202	.139	.138	.135	.161	.186	.666		
25 Visual Mem	.379	.273	.203	.335	.325	.324	-.041	.180	.265	.192	.353	.255	
26 Dich	.165	.095	.242	.271	.510	.278	.121	.270	.313	.304	.167	.246	.306
27 Some-all	.063	-.142	.028	.192	.379	.107	.267	.329	.203	.174	.075	.178	.087
28 Cardinal	.180	-.007	.058	.292	.296	.254	.140	.292	.184	.325	.219	.178	.390
29 Trans of Lgth	.240	.165	.157	.156	.283	.138	.114	.219	.304	.128	.147	.102	.151
30 Trans of Wgt	.161	.102	.105	.183	.108	.143	.194	-.087	.352	.077	.118	.129	.144
31 Seriation	.205	.130	.179	.300	.331	.297	.110	.339	.202	.306	.234	.167	.420
32 Cons of No.	.045	-.142	.013	.197	.187	.114	.207	.276	.264	.385	.116	.040	.246
33 Id Cons of Lgth	.125	.091	.152	.161	.405	.253	.192	.211	.299	.368	.266	.262	.413
34 Eq Cons of Lgth	.095	.081	.169	.148	.376	.294	.212	.252	.347	.418	.338	.240	.342
35 Id Cons of Wgt	.069	-.067	.088	.141	.377	.264	.160	.307	.294	.291	.177	.247	.174
36 Eq Cons of Wgt	.168	.102	.206	.218	.418	.154	.005	.336	.279	.294	.218	.235	.249
37 Arith Add	.022	-.003	-.180	-.021	.204	.007	.188	.134	.136	.121	.217	.243	.234

TABLE 34, continued.

Variables	26	27	28	29	30	31	32	33	34	35	36	37
26 Dich	1.000											
27 Some-all	.366											
28 Cardinal	.328	.311										
29 Trans of Lgth	.289	.290	.104									
30 Trans of Wgt	.036	-.050	.083	.138								
31 Seriation	.517	.174	.496	.190	-.015							
32 Cons of No.	.380	.304	.577	.109	.107	.604						
33 Id Cons of Lgth	.311	.197	.334	.163	.161	.187	.273					
34 Eq Cons of Lgth	.353	.126	.248	.094	.047	.192	.235	.675				
35 Id Cons of Wgt	.342	.207	.294	.210	.054	.411	.325	.462	.405			
36 Eq Cons of Wgt	.304	.189	.249	.276	.011	.387	.172	.410	.388	.654		
37 Arith Add	.329	.224	.377	.073	.000	.466	.453	.165	.113	.159	.098	1.000

Value of correlation coefficient significant at the .05 level = .195, and at the .01 level = .254 (two-tailed probabilities).

analysis. The unrotated factor loadings are given in Table A-2 of Appendix A.

Table 35 presents the rotated factor matrix (principle components using the varimax procedure) for the combined first and fourth grades. Factor 1 accounting for 21 percent of the total variance may be designated a "cognitive development" factor. Loading on this factor were all 12 of the CLD assessment battery tests and the three traditional Piagetian tasks including Dichotomies, Cardinality, and Transitivity of Length. Arithmetic addition and visual orientation memory also loaded on this factor. Other tests having loadings between .25 and .30 on this factor included Primary Addition of Classes, Seriation, and Conservation of Number.

The second factor which accounts for about eight percent of the variance may be designated "addition and multiplication of classes." Tests loading on this factor include the four tests specifically constructed to measure addition and multiplication of classes and also the traditional Piagetian task, Class Inclusion.

The third factor which accounts for about eight percent of the variance may be tentatively designated a "number concept" factor. Loading high on this test are Conservation of Number, Seriation, Cardinality, Arithmetic addition, and Co-univocal Multiplication of Relations; the problem-solving subtest of tree as well as the supraordinate-subordinate relationships involving tree also had loadings of about .32 on this factor.

The fourth factor accounting for about six percent of the variance, may tentatively be designated a "mixed" Piagetian concrete operations factor. Loading on this factor were two measures of conservation,

TABLE 35

ROTATED FACTOR MATRIX (PRINCIPAL COMPONENTS ANALYSIS UTILIZING VARIMAX PROCEDURES) FOR THE FIRST AND FOURTH GRADE SUBSAMPLES FOR THE YEAR 2 ASSESSMENTS (RANK ORDERING OF VARIABLES LOADING ($\geq$ .30) ON THE RESPECTIVE FACTORS ARE PRESENTED IN PARENTHESES)

	FACTORS								
Variables	1	2	3	4	5	6	7	8	9
Total levels of Eq. Tri.	.639 (9)	.161	.117	.092	.384 (4)	.007	.087	-.098	-.298
Sup-Sub for Eq. Tri.	.628 (11)	.018	.067	.093	.157	.002	.091	-.060	-.069
Prin for Eq. Tri.	.778 (6)	.148	.147	.180	.093	.112	.081	.136	.103
Prob Solv for Eq. Tri.	.848 (3)	.132	.029	.058	.119	.028	.095	.001	-.025
Total levels of Noun	.879 (1)	.065	.257	.121	.046	.081	.061	.109	.092
Sup-Sub for Noun	.822 (4)	.091	.146	.137	-.032	.025	-.056	.107	.191
Prin for Noun	.856 (2)	.043	.051	.027	.014	-.169	.020	.103	.119
Prob Solv for Noun	.678 (8)	.037	.002	-.142	-.015	.101	.078	.203	.412 (2)
Total levels of Tree	.681 (7)	.146	.260	.060	.064	.181	.179	-.054	-.113
Sup-Sub for Tree	.633 (10)	.076	.319 (7)	.216	-.103	.248	.070	.023	-.010
Prin for Tree	.797 (5)	.174	.208	.101	.151	.128	.051	-.021	.083
Prob Solv for Tree	.477 (12)	-.124	.319 (6)	-.056	.129	.006	.060	-.129	-.398 (3)
Prim Add of Class	.253	.824 (2)	.005	.058	-.005	.120	.022	.054	.005
Sec Add of Class	.127	.846 (1)	-.083	.029	-.048	.115	-.164	.060	-.104
Bi-univ Mult of Class	.001	.737 (3)	-.017	.144	.068	.016	.076	.127	.153
Co-univ Mult of Class	.239	.611 (4)	.211	-.090	.127	.086	.209	.019	.311 (5)
Class Incl	.242	.330 (5)	.070	.418 (4)	.244	.089	.352 (4)	.106	.124
Comb Reas	.229	.144	.110	.094	.203	.124	.029	-.035	.674 (1)
Add of Asym Rel	-.074	.075	.185	-.149	.248	.036	.532 (2)	.426 (3)	-.253
Add of Sym Rel	.106	.119	.243	.260	.185	.011	.504 (3)	-.302 (4)	.164
Bi-univ Mult of Rel	.122	.139	.121	.281	.166	.057	.195	.693 (2)	.038
Co-univ Mult of Rel	.032	.151	.336 (5)	.121	.402 (3)	.051	.287	.228	.335 (4)
Aud Seq Mem	.053	.251	.123	.058	.167	.793 (2)	.028	.088	.231
Aud Mem Span	.129	.084	.007	.101	.139	.873 (1)	.111	.031	-.040
Visual Mem	.422 (13)	.276	.285	.094	.264	.261	-.221	.041	.130
Dich	.417 (14)	.090	.266	.374 (6)	.072	.078	.279	.082	.140
Some-all	.228	-.084	.102	.132	-.018	.098	.776 (1)	-.016	.028
Cardinal	.335 (16)	.053	.636 (3)	.009	.244	.071	.151	-.030	.079
Trans of Lgth	.338 (15)	.124	-.128	.439 (3)	-.244	.075	.333 (5)	.273	-.016
Trans of Wgt	.074	.107	.013	-.067	.087	.047	-.129	.728 (1)	.045
Seriation	.278	.160	.740 (2)	.377 (5)	-.073	.079	.001	-.020	.139
Cons of No.	.269	-.091	.784 (1)	.080	.113	-.079	.167	.159	.022
Id Cons of Lgth	.210	.023	.072	.280	.732 (2)	.156	.045	.165	.031
Eq Cons of Lgth	.158	.025	.042	.246	.764 (1)	.164	.070	.115	.133
Id Cons of Wgt	.121	-.063	.214	.705 (2)	.352 (5)	.058	.081	.049	.043
Eq Cons of Wgt	.127	.137	.105	.799 (1)	.266	.077	.030	-.047	-.004
Arith Add	.330 (17)	-.176	.550 (4)	.046	-.062	.330 (3)	.069	.072	-.282
Percentage of total factor variance	30.9	11.7	11.4	9.4	8.9	7.6	7.5	6.6	6.1
Percentage of total variance	21.1	7.9	7.7	6.4	6.1	5.2	5.1	4.5	4.2

Seriation, Transitivity of Length, Dichotomies, and Class Inclusion. Each area of the concrete operations is included in this factor although some specific areas such as Conservation of Length and Transitivity of Weight are not.

The fifth factor contributing to six percent of the total variance may be designated a "conservation" factor. Three of the four conservation tasks load heavily on this factor as do also Co-univocal Multiplication of Relations and the total levels of equilateral triangle.

The sixth factor may be designated "auditory memory." Word and digit memory loaded heavily on this factor as did arithmetic addition. Factors 7 and 8 both involve the addition and multiplication of relations and show no clear intertask patterns.

Factor nine appears to be an abstract problem-solving factor with the following tests loading heavily on it: Combinatorial Reasoning, problem solving for noun, problem solving for tree, Co-univocal Multiplication of Classes, and Co-univocal Multiplication of Relations.

Some similarity may be noted in the factors for the overall subject sample and the subsample of combined grades one and four. This should be expected inasmuch as the same students from grades one and four were involved in both factor analyses and also 25 of the tests were common to both factor analyses. The four similar factors are as follows. First, there is a cognitive development factor, based on the CLD assessment batteries, which accounts for the largest amount of the variance in both analyses. Second, there is an addition-and-multiplication-of-classes factor, based on the Brainerd *groupement* tests of logical operations, which accounts for the second largest amount of the variance in both subsample

analyses. The addition and multiplication of relations, which is a clear-cut factor when first, fourth, and seventh grades are combined does not retain its identity for the first and fourth grades, although it appears to contribute significantly to two of the factors (seven and eight, see Table 35 in the combined first and fourth grade subsample). Fourth, there is a memory factor in both subsample analyses. All three of the memory tests load heavily on this factor in the combined first, fourth, and seventh grades; two tests do for the first and fourth grade subsample.

Other factor analytic methods will be used on the final data collected in the latter two years of the study to determine empirically whether the same factors and related patterns are found by different analyses. This will permit drawing more definitive conclusions regarding the interrelationships among the CLD constructs and principles, those related to Brainerd's tests of the logical operations dealing with relations and classes, and those related to more traditional Piagetian tasks.

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APPENDIX A

RAW FACTOR MATRICES

TABLE A-1

RAW FACTOR MATRIX (PRINCIPAL COMPONENTS PROCEDURE) FOR THE COMBINED FIRST, FOURTH, AND SEVENTH GRADE SAMPLE FOR THE YEAR 2 ASSESSMENTS

Variables	FACTORS 1	2	3	4
Total levels of Eq. Tri	.781	-.166	.032	-.047
Sup-Sub for Eq. Tri.	.595	-.291	.038	.077
Prin for Eq. Tri	.874	-.145	.017	-.043
Prob Solv for Eq. Tri	.794	-.222	-.023	-.064
Total levels of Noun	.914	-.175	.007	.009
Sup-Sub for Noun	.810	-.181	-.089	.050
Prin for Noun	.828	-.274	-.026	-.100
Prob Solv for Noun	.735	-.184	-.035	.053
Total levels of Tree	.798	-.216	-.033	-.015
Sup-Sub for Tree	.750	-.226	.015	.057
Prin for Tree	.879	-.207	-.042	-.007
Prob Solv for Tree	.557	-.407	.084	-.097
Prim Add of Class	.605	.437	-.415	-.205
Sec Add of Class	.535	.454	-.500	-.279
Bi-univ Mult of Class	.461	.471	-.220	-.304
Co-univ Mult of Class	.577	.434	-.066	-.097
Class Incl	.535	.387	.182	-.059
Comb Reas	.512	.169	.133	.171
Add of Asym Rel	.222	.282	.518	-.295
Add of Sym Rel	.390	.100	.401	.131
Bi-univ Mult of Rel	.343	.355	.452	-.249
Co-univ Mult of Rel	.494	.352	.457	-.016
Aud Seq Mem	.375	.524	-.068	.593
Aud Mem Span	.441	.326	-.048	.612
Visual Mem	.665	.029	-.060	.201
Eigen Values	10.445	2.368	1.40	1.23

TABLE A-2

RAW FACTOR MATRIX (PRINCIPAL COMPONENTS PROCEDURE) FOR THE
COMBINED FIRST AND FOURTH GRADE SAMPLE
FOR THE YEAR 2 ASSESSMENTS

Variables	FACTORS								
	1	2	3	4	5	6	7	8	9
Total levels of Eq. Tri.	.658	-.184	-.012	-.086	-.144	.094	-.229	-.269	-.285
Sup-Sub for Eq. Tri.	.574	-.266	.015	-.125	-.087	.053	-.092	-.023	-.117
Prin for Eq. Tri.	.818	-.170	.136	-.100	.022	.069	-.014	.050	.056
Prob Solv for Eq. Tri.	.755	-.323	.191	-.150	-.034	.070	-.102	.012	-.120
Total levels of Noun	.872	-.329	.091	-.042	.043	.057	.041	.036	.063
Sup-Sub for Noun	.758	-.315	.214	-.113	-.005	.061	.119	.063	.147
Prin for Noun	.689	-.430	.210	-.263	.072	.044	.106	.012	-.013
Prob Solv for Noun	.590	-.220	.278	-.084	.194	.166	.237	.325	-.022
Total levels of Tree	.729	-.235	.036	.122	-.017	-.049	-.162	-.003	-.095
Sup-Sub for Tree	.712	-.214	.012	.154	-.033	-.058	-.101	.066	.196
Prin for Tree	.829	-.217	.137	.001	-.086	.055	.018	.012	-.062
Prob Solv for Tree	.414	-.422	-.215	.148	-.031	.023	-.196	-.244	-.164
Prim Add of Class	.445	.325	.590	.097	-.006	-.223	-.126	-.183	-.065
Sec Add of Class	.255	.328	.679	.125	-.052	-.150	-.179	-.299	.004
Bi-univ Mult of Class	.281	.511	.439	-.032	.035	-.241	.013	-.140	-.036
Co-univ Mult of Class	.506	.308	.340	.149	.091	-.227	.202	.023	-.239
Class Incl	.576	.385	-.039	-.203	-.020	-.165	-.105	.052	-.030
Comb Reas	.425	.237	.105	-.034	-.140	.045	.485	.318	-.033
Add of Asym Rel	.179	.250	-.274	.037	.583	-.022	-.236	-.102	-.285
Add of Sym Rel	.394	.194	-.285	-.031	-.172	-.396	.023	.181	-.251
Bi-univ Mult of Rel	.422	.368	-.093	-.204	.476	.128	-.062	-.093	.243
Co-univ Mult of Rel	.439	.424	-.230	-.010	.179	-.010	.291	.027	-.136
Aud Seq Mem	.397	.467	.105	.475	-.082	.275	-.087	.311	.064
Aud Mem Span	.374	.310	-.009	.444	-.119	.331	-.395	.341	.046
Visual Mem	.605	.094	.150	.205	-.158	.203	.145	-.145	.041
Dich	.648	.068	-.153	-.095	.009	-.166	-.003	.100	.113
Some-all	.393	.021	-.326	-.090	.222	-.334	-.241	.406	-.215
Cardinal	.601	-.038	-.277	.280	.043	-.093	.231	-.129	-.127
Trans of Lgth	.416	.065	.068	-.295	.171	-.204	-.334	.213	.305
Trans of Wgt	.165	.196	.155	-.075	.526	.355	.067	-.160	.228
Seriation	.624	.033	-.218	.290	-.084	-.323	.238	-.156	.330
Cons of No.	.546	-.113	-.444	.231	.241	-.171	.273	-.220	.065
Id Cons of Lgth	.506	.355	-.270	-.185	-.122	.399	.003	-.154	-.176
Eq Cons of Lgth	.467	.406	-.263	-.187	-.154	.396	.073	-.078	-.236
Id Cons of Wgt	.467	.304	-.436	-.245	-.266	.010	-.033	-.094	.238
Eq Cons of Wgt	.465	.363	-.249	-.263	-.400	-.093	-.143	-.127	.282
Arith Add	.453	-.250	-.328	.438	.112	.032	-.178	-.080	.164
Eigen Values	11.328	3.157	2.66	1.52	1.50	1.45	1.31	1.18	1.10

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